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# AQUIFER STORAGE AND RECOVERY ASSESSMENT, CITY OF KENNEWICK

## WRIA 31 Supplemental Water Storage Project

**Prepared for: WRIA 31 Planning Unit**

Project No. 030009-002-01 • October 24, 2005

Project funded through Ecology Grant No. G0500011

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# 1 Introduction

This report presents an assessment of the potential for using aquifer storage and recovery to meet peak water demands within the City of Kennewick's water service area, located within Water Resource Inventory Area (WRIA) 31. This supplemental water storage project was funded under Grant number G0500011 obtained by the WRIA 31 Planning Unit from the Washington State Department of Ecology (Ecology) under the Watershed Management Act.

Aquifer storage and recovery (ASR) refers to temporarily storing water in an aquifer for later recovery and use. In the 2000 session, the Washington State Legislature expanded the definition of "reservoir" in RCW 90.03.370 to include "any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project." In March 2003, Ecology adopted a regulation (Chapter 173-157 WAC) pertaining to ASR projects. This regulation defines water rights/permitting requirements for an ASR project, the process and information requirements for obtaining an ASR permit, and Ecology's process for reviewing ASR permit applications.

The City of Kennewick (City) encompasses approximately 90 percent of the WRIA 31 population. The 2002 City of Kennewick Water System Plan projects a water demand increase of 140 percent by the year 2021. Currently, Kennewick's water supply sources include a Columbia River diversion (with Treatment Plant) and a pair of Ranney collectors withdrawing shallow groundwater from Columbia River gravels. Ranneyt No. 5, which is in direct hydraulic connection with the river, produced 62 percent of the City's 2004 annual water supply. Therefore, a majority of water required to meet the City's summer/autumn peak demand is currently drawn from the Columbia River system at the time that flows are naturally lowest and potentially of greatest importance for instream resources. ASR may provide a viable mechanism to store surplus Columbia River water during the off-peak (winter) season, and make that stored water available to meet the late-season peak demand. As such, ASR provides a water supply alternative that can help maximize use of the City's existing production capacity by utilizing it more fully in the off-peak season, thus limiting or delaying the need to construct additional surface water treatment capacity which can be very costly in light of surface water treatment requirements. ASR has already been identified as a water supply alternative of importance in the City's 2002 Water System Plan and in the Quad Cities' (Kennewick, Richland, West Richland, Pasco) 2003 Regional Water Supply Feasibility Report (JUB Engineers 2003).

The primary objective of this assessment is to select a target ASR area within the City's water service area, and provide a detailed assessment of the target ASR area should the City choose to pursue future pilot testing and permitting of an ASR project to help meet multipurpose water demands within the population center of WRIA 31.

As per Chapter 173-157 WAC, information requirements for submitting to Ecology an ASR project application include:

- A description (conceptual model) of the hydrogeologic system pertinent to the project;
- A project operation plan describing pilot and operational phases of the project;
- A description of the project’s legal framework (water rights);
- An environmental assessment of potential adverse impacts to the surrounding area and its ecosystem;
- If required, a project mitigation plan to address potential adverse impacts associated with the project; and
- A project monitoring plan to verify the assumptions of the project conceptual model through pilot testing.

This assessment addresses three of those required elements:

- A description of the hydrogeologic conceptual model as currently understood from existing information;
- An environmental assessment of potential impacts associated with applying ASR in this area; and
- A project monitoring plan, which, in this initial assessment, represents a preliminary plan for ASR pilot testing.

The hydrogeologic conceptual model also includes some discussion of water rights for the source water, as well as recharge and recovery scenarios that can be applicable to a future project operation plan.

The remaining sections of this report include identification of a target ASR area within the City’s service area, followed by presentation of those three elements respectively. The report section addressing each element is organized generally consistent with the requirements for that element as per Chapter 173-157 WAC.

# 2 ASR Target Area

An initial task in this assessment was meeting with City personnel in September 2004 to survey the City's water service area and existing water supply infrastructure. Figure 1 depicts the City's water service area, water pressure zones, and existing and currently planned (short-term) water supply infrastructure. The infrastructure shown includes the City's Columbia River diversion, Ranney collectors, water treatment plant, water supply mainlines, and reservoirs.

The primary area considered for potential application of ASR is in the southwest part of the water service area; bound by Badger Road to the west, Highway 395 (Evergreen Highway) to the east, and Interstate 82 to the south. This area was delineated based on a preference to locate prospective ASR well(s) within existing water system pressure zones where growing future demand is anticipated and generally near existing water supply infrastructure (Figure 1).

Additional considerations for the ASR target area include both the geologic setting and the aquifer conditions. In order to prevent the unnecessary loss of water injected into the selected aquifer for storage, it is useful to have an aquifer that is horizontally and vertically confined to create a subsurface reservoir. It is also necessary to have an aquifer with a relatively high transmissivity to allow reasonable volumes of water to be recharged and subsequently recovered within specified timeframes. These hydrogeologic considerations are described further in Section 3.

Within this target area, choice of an actual ASR location would depend on a number of factors including City ownership or access to property on which to site an ASR well, proximity to the City's current or planned water distribution infrastructure, as well as the presence of potential critical areas that could constrain locations of new wells and/or associated infrastructure.

# 3 Hydrogeologic System Description

## 3.1 Geography

On the regional scale, the project area is located within the Pasco Basin, east of the Horse Heaven Hills, which descend from an elevation of approximately 1600 feet at the ridgeline west of Kennewick down to Lake Wallula and the Columbia River at an elevation of approximately 350 feet. The target ASR area is southwest of the Kennewick city limits, but within its water service area, in close proximity to planned storage reservoirs to be located on a 1,000-foot high northwest-trending ridgeline which is part of "The Rattles." Several canyons cut across the project area from south to north, with Coyote, Amon, and Zintel Canyons being the larger ones (Figure 1). The major drainage in the area is the Amon Wasteway, which flows north from the Horse Heaven Hills into the Columbia River. In addition, there are several aqueducts, canals, and lakes in the project area, which will be identified and discussed in greater detail in Section 4.2.2.

## 3.2 Geologic Setting

In order to limit potential loss of water recharged into the selected aquifer for storage, a preferred ASR location should be sited in an area where the selected aquifer is both horizontally and vertically confined to create a subsurface reservoir. Thus it is important to have a proficient understanding of both the geologic stratigraphy and structure within the project area. In order to accomplish this, detailed geologic cross sections were produced for the project area. These cross-sections provide information on the presence and thickness of the various basalt flows and sedimentary interbeds, as well as the location of faults and folds which define the structure within the project area.

### *3.2.1 Stratigraphy*

Figure 2 presents a detailed stratigraphic sequence of the Columbia River Basalt Group (CRBG) and the overlying sediments within the Pasco Basin, including the ASR target area (from Myers and Price 1981). The stratigraphy includes geologic formations, which are further subdivided into members, which can be subdivided further into individual basalt flow packages and intervening sedimentary interbeds. Figure 3 presents a surface geologic map of the project area based on a 1:100,000 scale mapping from the Washington Department of Natural Resources (2000), which was originally modified from Reidel and Fecht (1994). The surface geology of the project area is composed primarily of unconsolidated sediments consisting of alluvium, outburst flood deposits, loess, and mass wasting deposits (Qa, Qf, Ql, and Qls, respectively, on Figure 3). Beneath these surficial units are the Touchet Beds and Pasco Gravels of the Hanford Formation, which were deposited during glacial flood events of the Pleistocene epoch. Beneath the Hanford Formation is the Ringold Formation, which is composed of clay, silt, sand and gravel deposited in an alluvial environment (Myers and Price 1981).

Underlying the unconsolidated overburden of the Hanford and Ringold Formations is the bedrock of the Columbia River Basalt Group. Regionally, the CRBG is composed of (from youngest to oldest) the Saddle Mountains, Wanapum, Grand Ronde, Picture Gorge, and Imnaha Basalt Formations (Bauer and Hansen 2000).

Of primary hydrogeologic interest in the project area are the Saddle Mountains and Wanapum Basalt Formations. These are the basalt formations in which a majority of the water supply wells in the project area are completed and thus have the most data available. They also exhibit water quality, which though variable, is generally of better quality than at greater depth in the area. The Saddle Mountains Basalt Formation is composed of individual basalt flows or groups of flows termed (from youngest to oldest) the Ice Harbor (Tsih), Elephant Mountain (Tsem), Pomona (Tsp), Esquatzel (Tse), Asotin (Tsa), Wilbur Creek (Tsw) and Umatilla (Tsu) Members. The Wanapum Basalt Formation is composed of (from youngest to oldest) the Priest Rapids (Twpr), Roza (Twr) and Frenchman Springs (Twf) Members (Figure 2; Myers and Price 1981). Some of these individual flows may be absent at a specific location.

Sediments interbedded within the various members of the CRBG (deposited in times between basalt flows) are collectively considered part of the Ellensburg Formation. Interbeds found within the Saddle Mountains and Wanapum Basalt Formations include (from youngest to oldest): Levey (Tel), Rattlesnake Ridge (Ter), Selah (Tes), Cold Creek (Tec), Mabton (Tem), Quincy (Teq) and Squaw Creek (Figure 2; Myers and Price 1981). The lateral extent and thickness of the interbeds can often vary considerably. Depending on the composition, thickness, and lateral extent of the interbeds, they can act as either a boundary or conduit to groundwater flow.

To determine the stratigraphy beneath the ASR target area, well logs and well summary information for wells completed at depths greater than 500 feet were obtained from the Washington State Department of Ecology (Ecology) database. Wells greater than 500 feet in depth were examined because they were most likely to provide a complete stratigraphic description of the Saddle Mountains Basalt and the Priest Rapids (uppermost) Member of the Wanapum Basalt. Well logs and well summary information were obtained for a total of 68 wells within an 80-square-mile area surrounding the ASR target area. Figure 3 shows well locations with respective reported well yields in the vicinity of the ASR project area. Table 1 provides well summary information, including location (quarter-quarter section accuracy) and elevations based on the USGS digital elevation model (DEM) for these 68 wells.

The stratigraphy was determined primarily from well logs for 33 of the 68 wells within the project area. Based on the geologic map (Figure 3) and the stratigraphy from the well logs, two cross-sections were created in the ASR target area (Figures 4 and 5). Personal correspondence with Anna Hoselton of Ecology Central Regional Office (CRO) provided internal draft x-ray refraction (XRF) data on the stratigraphy of the DNR Red Mountain #1 Well (T09N/R27E-02) and West Richland's #7 Well (T09N/R27E-04) northwest of the project area shown on Figure 3. This information provides more definitive picks on individual stratigraphic member depths, based on mineralogic assemblages, than is otherwise available from well log review. Well logs at the northern end of the cross section A-A' were thus correlated to the Red Mountain #1 and West Richland #7 wells to make stratigraphic picks. The various members of the Saddle Mountains and Wanapum

Basalts, as well as the interbeds, were interpreted based on composition, color and thickness. Using this information, correlations were thus made from north to south on the A-A’ cross section and from west to east on the B-B’ cross section (Figures 4 and 5 respectively).

### 3.2.2 Geologic Structure

The major geologic structures (faults and folds) in the project area, taken from Reidel and Fecht (1994), are also identified on both the geologic map (Figure 3) and the cross sections (Figures 4 and 5). The anticlines in the project area are generally part of the Rattlesnake Ridge Anticline complex, referred to in the project area as “The Rattles.” This complex is composed of a series of northwest-striking, doubly plunging, asymmetric anticlines. The total length of the system is greater than 40 miles, with approximately 1,150 feet of structural relief. Anticlines in this complex form Badger Mountain and several other ridges in the ASR target area. A syncline, the parallel trough between adjacent ridges, generally is located between any pair of parallel anticlines. A concealed syncline (absent in surface expression) is associated with the Rattlesnake Ridge Anticline complex and is located in the project area within Sections 7 and 18 of Township 08N Range 29E (Figure 3). While the extent of the anticline axes (crests) are mapped only sporadically by DNR, we infer that they run generally continuously, parallel to the mapped surface expressions of the adjacent thrust faults (Figure 3). A northwest-trending thrust fault runs along the north side of the Rattlesnake Ridge Anticline complex. Thrust faults result from the same compressive forces as cause the anticlinal folding, with one block sliding up over the other. The southern plate of the thrust fault has been uplifted over the northern plate, with a displacement on the order of tens to hundreds of feet (approximately 250 feet, according to cross-section A-A’).

To the south of the Rattlesnake Ridge Anticline complex is the Webber Canyon anticline, which is part of the Horse Heaven Hills uplift. The Webber Canyon anticline is northwest-trending and approximately 3.25 miles in length. The Webber Canyon fault is located on the northern side of this anticline, with a maximum near-vertical displacement of approximately 260 feet and a length of approximately 5.6 miles (Department of Energy 1988; Reidel and Fecht 1994). The displacement is interpreted to be on the order of 100 feet in the project area based on cross section A-A’ (Figure 4).

Figure 6 is a schematic illustration of the interpreted structural evolution of the Rattlesnake Hills and Webber Canyon Anticline systems. In this interpretation, the anticlinal folding proceeds in response to regional compressive forces, with one of the anticline’s limbs eventually becoming overturned (folded past 90 degrees). Fractures form in this zone of maximum stress and deformation. As the compression continues, displacement occurs along the fractures, forming a thrust fault in which the upper block slides over the lower block. Over time, erosion gradually flattens the surface expression of the folding. In the project area, the folds persist, forming ridges that are locally eroded away in major drainages. For reference, the target ASR area is shown relative to structural elements presented schematically on Figure 6. The folds and faults are believed to represent important controls on groundwater flow in the project area, as described in following sections.

## 3.3 Target Aquifer for Storage

Based on the available data, the Wanapum Basalt Formation would provide the best aquifer for larger-scale water storage and recovery, as may be sought to supplement Kennewick's municipal water supply to meet peak demands. A candidate aquifer for water storage and recovery should ideally be both laterally and vertically confined, as well as have a relatively high transmissivity. Leakage of stored water from the reservoir, into either another aquifer or surface water, would make it unavailable for recovery from the ASR well.

Individual basalt flows within the Wanapum Basalt can range between a few inches and 300 feet in thickness. Basalt flows are generally composed of a basal colonnade, a thicker flow interior consisting of generally massive basalt, and a flow top. The flow top generally consists of vesicular basalt and clinker and is usually the most permeable water-bearing zone within the flow (Bauer et al. 1985). Where two stacked flows are in contact, the combined flow top and base are termed an interflow. The interflows represent the aquifer zones within the basalts, whereas the flow interiors are generally impediments to groundwater flow (except via fracture flow).

Review of published literature, aquifer test data, and well log information for the ASR target area indicates that the Wanapum Formation generally has a higher transmissivity than the Saddle Mountains Formation. Aquifer tests also indicate that within the Wanapum Basalt, the flow top of the Priest Rapids Member has the highest hydraulic conductivity (Department of Energy 1982). Table 2 presents a summary of aquifer hydraulic properties for both the Saddle Mountains and Wanapum Formations based on available regional information as referenced in the table. Overall, the statistical average (geometric mean) of the aquifer transmissivity data was calculated to be approximately 820 $ft^2$/day (6,100 gpd/ft) for the Saddle Mountains Basalt, and 11,300 $ft^2$/day (84,000 gpd/ft) for the Wanapum Basalt.

Well logs for several wells indicate moderate to high yields for wells tapping the Wanapum Basalt Aquifer in the project area, including: City View Orchard (8N/29E-17Q02) at 500 gallons per minute (gpm), Cummings (8N/28E-23D02) at 200 gpm, Southgate Water Company (8N/28E-23F01) at 1000 gpm, Badger Mountain Irrigation District (BMID) #4 (8N/28E-4Q01) at 400 gpm, BMID #2 (8N/28E-3R01) at 576 gpm, and Willowbrook (9N/28E-36P01) at 1,200 gpm (Figure 3). The Brinkley well (8N/29E-17Q01), located within the ASR target area, reportedly produced 450 gpm (maximum rate of pump) for several years during the construction of Interstate 82. Although the Brinkley well (8N/29E-Q01) is completed within both the Quincy and Roza Members of the Wanapum Formation, it still demonstrates that a well completed within the Wanapum Formation could produce relatively high yields. Furthermore, it is uncertain whether these reported well yields were limited based on the well's screen/pump/pipe capacity and/or water rights, rather than aquifer yield characteristics.

Although sedimentary interbeds within basalt formations may be locally transmissive and thus function as aquifers, in general, they are believed to impede vertical movement of water and act as a vertically confining unit or an aquitard across most of the region (Whiteman et al. 1994). The Wanapum Formation is overlain by the regionally extensive Mabton interbed, which is generally composed of volcanic tuffstone, clayey sandstone,

sandstone interlayered with siltstone, and silty clay (Myers and Price 1981). The fine-grained sediments of the Mabton interbed likely make it a confining unit. Generally, in the ASR target area, the Mabton interbed is relatively thick and extensive, thus vertically confining the Wanapum Basalt Aquifer.

Folds and faults may laterally confine groundwater flow in the ASR target area. Newcomb (1961 and 1969) theorized that tight anticlinal folding of basalt forms breccia and fault gouge between the individual flows near the axis of an anticline, which decreases the transmissivity of the basalt and impedes groundwater flow across the anticlinal crest. A hydrogeologist from Ecology’s Central Regional Office confirmed that, based on his experience regionally, the anticlines typically do represent restrictions to lateral flow (John Kirk, personal communication, February 2005). Fault gouge may also decrease the transmissivity of the basalts in the areas surrounding thrust faults. Golder Associates (2001) indicated that a small fault exposed on the southeast side of Badger Mountain was “broken and rubbly”, with the presence of abundant clay or fault-gouge between the rock fragments. The pumping test performed at the Willowbrook Well (T9/R28E-P01 at north end of cross section A-A’), in January 2001 indicated the presence of a low transmissivity boundary, which is likely caused by a thrust fault inferred to be located approximately 2,000 feet south of the well (Golder Associates 2001a). Therefore, in the ASR target area, the Wanapum Basalt Aquifer appears to be laterally confined by the thrust fault and anticlines associated with the Rattlesnake Ridge and Webber Canyon Anticline complexes to the north and south, respectively.

Due to the relatively high transmissivity of the Wanapum Formation and the presence of the relatively thick and extensive Mabton interbed that overlies and confines it, the Wanapum Formation would likely provide the best aquifer for water storage and recovery. The uppermost portion of the Wanapum Basalt, the Priest Rapids Member, is documented to be a productive aquifer in the region and can provide some cost savings relative to exploring deeper members of the Wanapum which are currently less explored and developed.

Therefore, we recommend targeting the Priest Rapids Member of the Wanapum Basalt as the target aquifer for prospective ASR pilot testing in the target area.

The underlying member of the Wanapum, the Roza member, is also tapped for water supply in the project area (Figure 4). This member, although deeper and thus more expensive to drill new wells into than the Priest Rapids member, could also be a prospective target aquifer, particularly if suitable existing wells tapping that aquifer zone were identified as available for ASR pilot testing.

Based on the available hydrogeologic information (Figures 3, 4, and 5), the area targeted for prospective ASR would be in Sections 17 or 18 of Township 08N Range 29E (Figure 3). This area is roughly a mile south of the City’s current and proposed reservoir locations on the top of the “Rattles” (Figure 1). In terms of hydrogeology, this target area was chosen for the following reasons:

- The Priest Rapids Member of the Wanapum Basalt is relatively thick (approximately 200 feet) and believed to have a relatively high transmissivity.

- The overlying Mabton interbed is relatively thick (approximately 40 to 80 feet) and believed to provide vertical confinement to the target aquifer. The Mabton appears to thin to the east (Figure 5), suggesting the western portion of this target area may afford somewhat better confinement to the target aquifer zone.
- The folds and thrust fault of the Rattlesnake Ridge Anticline complex and Webber Canyon thrust fault/anticline are believed to provide lateral confinement to the target aquifer on the north and south, respectively. However, the area is believed to be far enough from the geologic structures (hydraulic boundaries) so as to not adversely impact the aquifer productivity immediately surrounding prospective ASR well(s).

As described in Section 2, choice of an actual ASR location would depend on a variety of factors including City access to an ASR well site on which it can exercise sanitary control for a municipal supply source, proximity to City water distribution infrastructure, and proximity to critical areas that could constrain well siting.

As required by WAC 173-157-120 for a hydrogeologic conceptual model, the following report subsections describe our current understanding of several parameters pertaining to the target aquifer. These include estimates of lateral and vertical aquifer extent, whether the aquifer is confined or unconfined, permeability and transmissivity, total storage volume available, as well as potential for physio-chemical changes in the aquifer as a consequence of recharge. Because a pilot test has not been conducted, all of the following information is based on available data and would be expected to be refined if an ASR pilot test is conducted.

### 3.3.1 Lateral and Vertical Extent

On a regional scale, the Wanapum Formation is laterally extensive over the entire Pasco Basin with a thickness of greater than 1,000 feet in the project area (Whiteman et al. 1994). In the project area, the Priest Rapids Member of the Wanapum Formation is laterally extensive over the entire project area, with a thickness ranging between 150 and greater than 250 feet (Figures 4 and 5). This range of thickness is fairly consistent with that determined for the Priest Rapids Member at the Hanford Site (between 205 and 227 feet) located northwest of the project area (Myers and Price 1981). Well logs on the eastern portion of cross section B-B' (8N/29E-15P01, 8N/29E-22A01 and 8N/29E-22A02) indicate a Priest Rapid Member thickness of up to 400 feet; however, the stratigraphy in this area was more difficult to determine due to the limited data and the well locations between the anticline and the fault. In the ASR target area , the top of the Priest Rapids Member (target aquifer) is estimated to be encountered at an elevation of roughly 350 feet (MSL), equating to depths between 500 and 600 feet depending on ground surface elevation. The aquifer unit in this area is estimated at approximately 200 feet thick and the Mabton interbed (overlying confining unit) at between 40 and 80 feet thick (Figure 5).

### 3.3.2 Confined or Unconfined

As stated in the previous sections, the Priest Rapids Member is confined by the overlying Mabton Interbed. On a regional scale, the Mabton interbed is generally composed of volcanic tuffstone, clayey sandstone, sandstone interlayered with siltstone, and silty clay (Myers and Price 1981). According to the available well logs, the Mabton interbed in the project area consists of clay with some sand and gravel. Static water levels for wells completed within the Priest Rapids Member of the Wanapum Formation are well above the top of Priest Rapids, confirming a confined aquifer in this area (Figures 5 and 6).

### *3.3.3 Hydraulic Properties*

Table 2 presents a range of values for the hydraulic conductivity (ft/day), transmissivity ($ft^2$/day), and storativity (dimensionless) of the Saddle Mountains and Wanapum Basalt Aquifers in the region. Hydraulic conductivity is a quantitative measure of an aquifer's ability to transmit water; the term is often used interchangeably with permeability but permeability is typically a qualitative term. Transmissivity is hydraulic conductivity multiplied by aquifer thickness, and is a measure of how much water can move through the aquifer and thus the aquifer's productivity. Storativity is the product of specific storage and aquifer thickness, where specific storage is defined as the volume of water (cubic feet) that a 1 cubic foot volume of aquifer releases from storage when the water level drops 1 foot.

The aquifer parameter values in Table 2 were compiled from published literature, analysis of aquifer test data, and rough estimates derived from well test specific capacity data. Table 2 also lists the sources from where the parameter values were derived, and whether the values were derived from model calibrations or aquifer tests. Based on the regional data, the best estimates of hydraulic conductivity for the Wanapum Basalt Aquifer ranged between 3 and 66 ft/day, with a geometric mean of 19 ft/day. The best estimates of transmissivity for the Wanapum Basalt Aquifer ranged between 1,300 and 51,500 $ft^2$/day, with a geometric mean of 11,300 $ft^2$/day. The reported storativity of the Wanapum Formation ranged between $3 \times 10^{-6}$ and $6 \times 10^{-3}$ for the various published data sources. However, because the ranges of storativity varied greatly depending on the source, the average of the geometric mean values reported from each data source was calculated and then the average of those values was chosen as a representative storativity for the Wanapum Basalt Aquifer ($4 \times 10^{-4}$). This value is relatively close to the value ($2 \times 10^{-4}$) provided from a pumping test near the City of Walla Walla (Price 1960).

Data from several aquifer tests previously performed on wells within the project area corroborate the mean values in Table 2. In January 2001, pumping tests were performed on the City of Richland's Willowbrook Well (9N/28E-36P01), which is completed in the Priest Rapids Member of the Wanapum Formation and, although on the other side of a thrust fault, is relatively close to the ASR target area (Figure 3). From analysis of the pumping test data, a hydraulic conductivity of 34 ft/day and a transmissivity of 9,000 $ft^2$/day were estimated (Golder Associates 2001a). A pumping test was also performed on Badger Mountain Irrigation District (BMID) Well #4 in February 2002, which is also completed in the Priest Rapids Member of the Wanapum Formation. Based on specific capacity data, the aquifer transmissivity for the BMID Well #4 was estimated to range between 20,000 and 26,000 $ft^2$/day (Golder Associates 2003). Therefore, it is reasonable to assume, as a starting point for planning a potential ASR pilot test, that a transmissivity of 11,300 $ft^2$/day (84,000 gpd/ft), based on the geometric mean of a range of values, is a representative transmissivity for the target aquifer in the project area (Priest Rapids Member of Wanapum Basalt).

### *3.3.4 Total Storage Volume Available*

WAC 173-157-120 specifies estimation of the total storage volume available in the target storage aquifer. While this could be estimated, it would depend on how many ASR wells might be used for storage and spread over what area. Likely the more pertinent question to address is whether the target aquifer has sufficient storage volume around an ASR well(s) to accommodate the storage volume desired of an ASR program. As depicted on the geologic cross sections (Figures 4 and 5), water levels in wells completed solely in the Priest Rapids member (Twpr) typically have water levels in the range of 50 to 80 feet above the top of the Priest Rapids and 400 to 500 feet below ground surface. This suggests that, while there is excess pressure in the confined aquifer, the aquifer could be pressurized further without concern for heads approaching ground surface throughout the target area. This capacity to accommodate additional aquifer pressurization, as could occur during artificial recharge via ASR well(s), equates to available storage capacity in the aquifer.

Related parameters of interest in designing and evaluating a prospective ASR program are the anticipated water level changes with distance, and the radius of influence, about an ASR well.

The amount of drawdown or mounding with respect to distance from the pilot test well can be calculated from the equation (Driscoll 1986):

$$dh = \frac{264Q}{T}\log\frac{0.3Tt}{r^2S}$$

where:

dh is the amount of drawdown or mounding (feet), Q is the pumping/injection rate (gpm), T is the aquifer transmissivity (gpd/ft), t is the time of continuous pumping/injection (days), r is the distance from the well (feet), and S is the aquifer storativity (dimensionless). Using the above equation, and an assumed transmissivity of 11,300 $ft^2/d$ and storativity of $4 \times 10^{-4}$ produces a maximum drawdown or mounding of approximately 25 feet in the aquifer immediately outside the well (r = 1 foot) over a pumping or recharge period of 90 days at 800 gpm. Theoretically, the mounding or drawdown in the aquifer will be the same magnitude for recharge or pumping, respectively, at a set rate but only different in direction (mounding vs. drawdown). Figure 7 demonstrates the relationship of estimated drawdown or mounding in the aquifer versus radial distance from a well using the assumptions above.

This equation can also be rearranged to estimate radius of influence, which is that distance away from the well (initially assumed to be the same in all directions radially from the well) at which groundwater mounding from recharge injection, or groundwater drawdown from recovery pumping, is negligible. For the assumed parameter values above, the radius of influence is estimated to approximately 75,000 feet or 14 miles. This equates to a radial area of roughly 630 square miles. The presence of structures which inhibit groundwater flow would also limit the lateral propagation of the radius of influence.

The radius of influence can also be estimated from the equation (Fetter 1994):

$$r = \sqrt{\frac{2.25Tt_0}{S}}$$

where:

r is the radius of influence (feet), T is the transmissivity ($ft^2$/day), $t_0$ is the time (days), and S is the storativity (dimensionless). Theoretically, radius of influence is independent of recharge/pumping rate as this equation indicates. Using the above equation and the same parameter values as listed above, the calculated radius of influence within the aquifer, assuming recharge or recovery for a 3-month period (90 days), is approximately 81,000 feet (15 miles) or a radial area of approximately 740 square miles. This is similar to the estimate above.

Despite these theoretical estimates for radius of influence, we expect, based on experience and the presence of mapped geologic structures, that drawdown or mounding would be indistinguishable from background water level fluctuations within a few miles of an ASR well in the target area.

### 3.3.5 Source Water for Storage

The source water for storage in a prospective City of Kennewick ASR program would be water from its distribution system which has been treated to meet drinking water standards. The City's primary sources of water include a Columbia River diversion with water treatment system and a pair of Ranney collectors that withdraw shallow groundwater from the Columbia River gravels along the river. Certificated water rights for these sources are as follow:

| Water Right Control No. | Priority Date | Source | Instantaneous Water Right in gpm (and cfs) | Annual Volume Water Right in Acre-Feet/Year |
|---|---|---|---|---|
| S4-25479C | 4/10/77 | Columbia River | 25,000 gpm (55.7 cfs) | 15,680 |
| 3897 | 2/27/57 | Columbia Park Ranney Collectors | 13,500 gpm | 5,600 |

At any given time, the mix of surface water and groundwater in the distribution system can be variable depending on demand.

The Ranney collectors have a combined production capacity of about 14 MGD. The City is in process of upgrading the capacity of their surface water treatment plant from 7.5 million gallons per day (MGD) to 15 MGD to help meet projected future peaking demand. This will increase total production capacity from 21.5 to 29 MGD. We expect that there will be surplus production capacity in the winter months when overall demand is lower. This surplus production capacity represents the source water potentially available for subsurface storage and subsequent recovery to meet summer peak demand.

Table 3 presents the most recent (2004) monthly water production, expressed as average daily production (MGD), based on Water Production Reports provided by the City. With the surface water treatment plant at 7.5 MGD capacity, the data indicate that there is currently a surplus supply capacity to meet peak daily demand during all months, with greater than 4 MGD excess capacity during the peak production months of July, August, and September. Projected estimates of future monthly water production for the year 2024 (20-year planning horizon) are also projected in Table 3, based on Population Derived Water Demand Estimates provided by the City. These estimates assume that the City's projected increase in total annual water production between 2004 actual values and 2024 projected values is applied uniformly to the 2004 monthly water production data. Average daily demand is projected to increase by 32 percent, whereas peak daily demand is projected to increase by 94 percent, over this 20-year planning horizon (Table 3).

Based on these projections, and a 29 MGD total production capacity (assuming no additional source capacity is developed by 2024), there should still be surplus production capacity to meet 2024 peak daily demands during the fall through spring months, but insufficient capacity to meet peak demands from May through September. Figure 8 illustrates the seasonal timing of current (2004) and projected future (2024) demand (in brown) and the resulting surplus production capacity potentially available for storage (in blue). This illustrates the seasonal availability of excess production capacity potentially available for storage in the winter. Both average and peak demands are illustrated for both years.

It is important to note that the projected demands for 2024 provided by the City do not include the 10 MGD of water production estimated to potentially be needed for major industrial use as assumed in the City's 2002 Water System Plan. If major industrial development does occur within Kennewick over the next 20 years, the surplus capacity estimated here (Figure 8) would be correspondingly less.

For reference in evaluating prospective ASR flow rates and timing, Table 4 presents a range of water volumes (acre-feet) that could be stored under a range of average flow rates and timeframes for storage. For example, storing an average of 1 MGD (approximately 700 gpm continuous) of surplus water continuously for 5 months provides a stored volume of approximately 560 acre-feet; 2 MGD (approximately 1,400 gpm) continuously for 2 months provides about 370 acre-feet of stored water, etc. (Table 4).

The seasonal timing of greatest surplus production capacity occurs in the winter and spring months, generally corresponding to the period of increasing flows in the Columbia River. Peak flows typically occur in early June. The upper plot on Figure 9 shows average daily flow hydrographs over the water year (October-September) for the Columbia River at the two gaging stations closest to the City of Kennewick: at Pasco upstream of the Snake River confluence and at McNary Dam downstream of that confluence. Note that the periods of gaging record at each location are much different: water years 1965-2004 for McNary Dam but only 1964-1966 at the discontinued Pasco station. The flows in the Columbia River are regulated by dams, the Priest Rapids dam upstream of Kennewick and McNary dam downstream of it. The hydrographs shown on Figure 9 do not represent the natural flow condition, rather they represent the Corps of Engineers' management of flows for hydropower generation and other uses.

The lower plot on Figure 9 shows McNary Dam flows during average flow years (50 percent exceedence flows) and low flow years (90 percent exceedence flows) relative to regulatory instream flow minimums at McNary Dam (Chapter 173-563 WAC). These regulatory minimum instream flows are considered appropriated water rights with priority dates at the effective date of the Chapter 173-563 WAC rule (June 24, 1980). The City's certificated water right for Columbia River diversion has a priority date preceding the instream flow rule, and thus is not subject to interruption based on minimum instream flow requirements in Chapter 173-563 WAC. The City shares a newer surface water permit with the Cities of Richland, Pasco, and West Richland. This permit is subject to interruption.

Although the City's certificated water rights are not constrained by instream flow minimums, an ASR program using Columbia River water could have a secondary benefit to fish in the river while helping meet increased peak demand in the future using existing production capacity. There should be a net benefit to Columbia River fish resources by diverting additional water for storage in the winter/spring and then using that stored water, while diverting lesser quantities from the river, during the peak demand months when flows are lowest and of greatest importance for fish resources. The National Research Council's 2004 report, Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival (National Academy of Sciences 2004), states that:

> *"The pronounced seasonality of withdrawals and the sharp differences in the effects of withdrawals according to season are key messages…. The data show that January withdrawals have very little effect on the overall flows of the Columbia, but that during July and August, current withdrawal volumes have noticeable effects on mainstem flows, especially during lower-than-average discharge years."*

Therefore, diverting peak winter/spring Columbia River flows, storing that water in the subsurface, and subsequently recovering it for summer use may represent a way to meet City of Kennewick's projected future peak water demands with the existing production capacity, thus reducing summer diversions from the Columbia River to the benefit of fish. This could be an additional consideration in determining that an application to Ecology for an ASR permit would be in the public interest, as well as potentially securing state funding for an ASR program.

### *3.3.6 Groundwater Quality and Potential for Physio-Chemical Changes*

Groundwater quality data were acquired from both the Washington State Department of Health (DOH) and the United States Geological Survey (USGS) for wells completed within the Wanapum Basalt Aquifer in the project area. Additional water quality samples were collected by Aspect Consulting from select wells tapping the Wanapum on April 26 and 27, 2005. These samples were collected in an effort to fill in existing water quality data gaps and provide a better understanding of the target aquifer water quality in the ASR target area. For this sampling, we coordinated with City personnel to obtain contact information for well owners. We were able to obtain access to four wells tapping the Wanapum for water quality sampling; we also coordinated with other well owners regarding water level measurements as described in Section 3.4. Some of these wells are also completed partially within the Saddle Mountains Aquifer. We also collected one sample of water from the City's distribution system adjacent to their Zone 3 Reservoir (28th and Irving) (Figure 1); this is representative of the source water that could be used for storage in the aquifer. These source water quality data are discussed further in Section 3.10.

Water quality sampling of the water supply wells involved collecting water from the wellhead prior to treatment or storage tanks, generally consistent with protocols outlined in the Quality Assurance Project Plan (Aspect Consulting 2004). All wells were pumping prior to sample collection. In addition to measuring field parameters (temperature, conductance, pH, dissolved oxygen, redox potential, and turbidity) for each water sample, the presence of methane and hydrogen sulfide was screened in the field using a GEM™ 2000 landfill gas extraction meter and hydrogen sulfide meter, respectively. Methane is an issue for groundwater quality at Richland's Willowbrook well (completed in the target aquifer about 3 miles northwest of the ASR target area; Figure 3). To screen for these gasses, the well water was directed into a closed container fitted with a port to allow sampling of the headspace (air) above the water. The water container was agitated and allowed to sit for a few minutes while gas measurements were collected.

The groundwater samples were analyzed for common cations (calcium, magnesium, sodium, potassium), common anions (bicarbonate, chloride, sulfate), alkalinity, total dissolved solids (TDS), and dissolved iron and manganese. These parameters allow determination of general water quality type and comparison with historical data for the project area. One well located near the middle of the ASR target area, Mr. Harold Brinkley's domestic well (8N/29E-17E01), and the sample of prospective source water from the City's distribution system (28th and Irving Reservoir) were analyzed for these constituents plus a comprehensive list of other parameters, including all parameters with drinking water standards. The additional constituents analyzed for these two water samples included metals, cyanide, fluoride, bromide, silica, ammonia, total organic carbon, radiologicals (radium-226, radium-228, gross alpha activity, gross beta activity, tritium, strontium-90) and byproducts of chlorine disinfection (trihalomethanes and haloacetic acids). These data allow a general comparison of water quality for prospective ASR source water and ambient groundwater in the target aquifer for the purposes of generally evaluating expected compatibility of the two water qualities and potential concerns for compliance with the antidegradation policy under the state's Ground Water Quality Standards (Chapter 173-200 WAC). The antidegradation policy requires that any permitted activity not degrade existing groundwater quality, except under certain limited circumstances.

Table 5 provides a summary of groundwater quality data for both the Saddle Mountains and Wanapum Basalt Aquifers, including data collected for this study and older data collected by others. Information on the wells, including completion aquifer(s), is also provided. Some of the older data include analytes not included in the April 2005 analyses for this study. Table 5 also includes regional average concentrations of various constituents for the two aquifer units (from Steinkampf 1989). Drinking water standards - Federal and State Maximum Contaminant Levels (MCLs) - are also listed for comparison, and concentrations above these standards are highlighted.

Based on the existing data from the project area, groundwater in the Wanapum Aquifer generally meets primary drinking water standards, which are based on health effects. Some constituents, namely specific conductance, iron, and manganese, in some wells are above secondary standards which are based on aesthetic effects (taste, odor, color, etc). All of the wells in the project area with groundwater quality data have sodium concentrations above a 20 mg/L drinking water standard that is based on a federal guideline to protect persons requiring low sodium in their diet. The elevated sodium concentrations are interpreted to be naturally occurring, due to the dissolution of minerals within the basalt formations (Vacarro 1999).

The temperature of the groundwater from the various wells completed within the Wanapum Basalt Aquifer ranges between approximately 46 and 78 °F. There is no drinking water standard for temperature, but elevated temperatures are less aesthetically appealing for drinking water purposes. Steinkampf (1989) determined the mean temperature of groundwater in the Wanapum Aquifer on a regional scale to be approximately 60 °F, based on 410 water analyses. Wells within the project area that have reported water temperatures well above that average temperature include: John Michel (8N/28E-9F01) at 78 °F, Trish Mahaffey (8N/28E-23R01) at 70 °F, Willard Campbell (8N/29E-22A02) at 73 °F, and Richland's Willowbrook well (9N/28E-36P01) at 70 °F. Based on the limited data, these wells with relatively higher groundwater temperatures are generally closer to the thrust faults (Figure 3).

Within the ASR target area, the Harold Brinkley domestic well (8N/29E-17E01) had a water temperature of 63 °F when measured for this study in April 2005. The Brinkley irrigation well (8N/29E-17Q01) has the lowest reported water temperature (46 °F in 1988). This well is completed in the Roza member of the Wanapum, below the Priest Rapids member. Typically, groundwater temperature within the regional basalt aquifers is warmer with increasing depth, therefore this reported temperature reading is considered suspect. This well was not operating during our field visit in April 2005 so water temperature could not be measured.

Wanapum Aquifer wells in the project area with historical dissolved oxygen (DO) data have low concentrations (0.1 to 0.7 mg/L), suggesting anoxic (reducing) conditions in this aquifer. The elevated concentrations of dissolved iron and manganese and the presence of methane in Richland's Willowbrook well (9N/28E-36P01) are consistent with anoxic groundwater in the target aquifer regionally. The Willowbrook well is equipped with an aeration tower to remove dissolved methane and thus allow its use as a municipal drinking water source. These anoxic conditions are consistent with sampling of Wanapum wells in the Glade-Fourmile subbasin of WRIA 31, to the west of Kennewick (Garrigues 1996; Aspect Consulting 2005).

However, DO data collected in April 2005 by Aspect Consulting in select wells within the project area indicate aerobic (oxygenated) groundwater (4.0 to 6.7 mg/L). Some of these wells are completed across the overlying Saddle Mountains units also, which could be contributing to higher DO conditions in the wells. These data are more consistent with Steinkampf's (1989) reported regional average DO concentration (5.2 mg/L) for the Wanapum Basalt Aquifer. The lack of measurable methane or hydrogen sulfide in groundwater from wells in the project area during this study is generally consistent with more aerobic conditions. In general, higher DO conditions equate to better water quality for drinking water, and thus more amenable to ASR. The collective data suggest that the DO conditions can be variable within the project area, depending on the location and geologic unit of well completion. Two of the wells with historically low DO concentrations are completed within the Quincy interbed or Roza Member of the Wanapum Formation (8N/29E-22A02 and 8N/29E-17Q01). Decomposition of organic matter in the sedimentary beds may explain low DO concentrations in groundwater. In addition the Willowbrook and 8N/29E-22A02 wells are relatively close to thrust faults, which may have an influence on groundwater quality. Based on analysis across the Hanford area, Johnson et al (1993) hypothesized that methane in groundwater of the Columbia River Basalt Group is the result of upward migration of deep-seated groundwater from older coal beds underlying the entire Columbia River Basalt sequence.

Concentrations of radiologicals (radium-226, radium-228, gross alpha activity, gross beta activity, tritium, strontium-90) measured in the sample from the Brinkley domestic well were below respective drinking water standards.

Byproducts from chlorine disinfection can include trihalomethanes and haloacetic acids. These are of interest primarily with respect to the quality of treated source water to be stored, since they are generally not expected in ambient groundwater. THMs and HAAs were not detected in the groundwater sample collected in April 2005 from the Brinkley domestic well (Table 5). The source water quality is discussed in Section 3.10.

#### 3.3.6.1 Groundwater Types

Based on groundwater composition data from Table 5, a Piper diagram was created for wells completed within the Wanapum Aquifer in the project area (Figure 4). The Piper diagram allows quick visual comparison of groundwater quality types for different wells based on the relative concentrations of the major cations (calcium, magnesium, and sodium) and major anions (bicarbonate, sulfate, and chloride). Groundwater types are named based on various combinations of the predominant cations and anions (e.g., calcium bicarbonate water type). They can be indicative of groundwater residence time and thus position within a regional flow system (e.g., near recharge area or not). In general, bicarbonate water types provide the best drinking water quality, whereas sulfate and chloride water types are less desirable.

On a regional scale, calcium-magnesium bicarbonate is the dominant groundwater type within the Columbia River Basalt Group. Sodium bicarbonate is the next most prevalent type, and calcium-magnesium sulfate-chloride is the least prevalent groundwater type (Vaccaro 1999). The average compositions of groundwater in both the Saddle Mountains and Wanapum Basalt Aquifers (from Steinkampf 1989) are also illustrated on the Piper diagram for reference. Based on the Piper diagram, all three water types are found within the project area (Figure 10).

Groundwater from the Willard Campbell Well (8N/29E-22A02), roughly 3.3 miles southeast of the target ASR location, consists of the calcium-magnesium sulfate-chloride type. Steinkampf (1989) found that groundwater of this type was associated with an overburden thicknesses of less than 100 feet and DO concentrations of greater than 5 mg/L, which suggests that the waters were recharged fairly recently. The Willard Campbell Well is located relatively close to an anticline and thrust fault associated with the Rattlesnake Ridge Anticline complex (Figure 3). This area is characterized by the absence of any overburden material and the absence or presence of a relatively thin confining unit (Mabton interbed) between the Saddle Mountains and Wanapum Formations. These circumstances may allow for oxygenated recharge reaching the Wanapum Formation in the vicinity of this well.

Groundwater from the John Michel (8N/28E-9F01), Harold Brinkley irrigation (8N/29E-17Q01), Earl Gilliam (8N/29E-17H01), and Greg and Sandi True (8N/28E-23D01) wells are of the sodium bicarbonate type. Within the Columbia River Basalt Group, sodium bicarbonate waters are found to occur further downgradient in the flow system and deeper within the aquifer than calcium-magnesium bicarbonate waters (Steinkampf 1989). Hearn and others (1995) proposed that sodium concentrations increase with residence time within the flow system. This would suggest that, in the area of the John Michel, Harold Brinkley, Earl Gilliam and Greg and Sandi True wells, infiltration recharge to the Wanapum Basalt Aquifer is limited by the overlying Mabton interbed. The groundwater type data also suggest that these wells are downgradient within the flow system and therefore have higher sodium concentrations due to longer groundwater residence times. Groundwater flow directions and gradients are discussed in greater detail in the following section.

Of the limited groundwater composition data available, the Brinkley domestic well (8N/29E-17E01) or the Brinkley irrigation well (8N/29E-17Q01) may be most likely to represent ambient groundwater quality conditions in Wanapum Aquifer beneath the ASR target area, depending on the exact unit of completion and location for a prospective ASR well. This is based on both the proximity of these wells and geologic structure of the area.

#### 3.3.6.2 Summary of Target Aquifer Groundwater Quality

Overall, ambient groundwater quality in the target aquifer area appears to meet primary drinking water standards. Concentrations of dissolved iron and manganese are above secondary standards (based on taste etc.) in some wells. The data suggest that groundwater quality in the ASR target area is somewhat better (e.g., lacking methane) than that at Richland’s Willowbrook well which completed in the target aquifer to the northwest. Elevated groundwater temperature (60 to 75 °F) appears to be consistent in the Wanapum Aquifer across the region. Note that the evaluation of groundwater quality by aquifer is complicated by the fact that many of the wells with data are completed across more than one geologic member. Data from these wells may represent a composite of groundwater quality between aquifers depending on how much water is contributed to the well from each unit.

## 3.4 Groundwater Flow Directions and Rates of Movement

Figure 11 presents hydrographs for select wells interpreted to be tapping the Wanapum Basalt Aquifer in the project area. The hydrographs, which are based on limited groundwater level measurements, indicate stable or rising water levels over time. This is consistent with the fact that extensive groundwater pumpage does not occur in the area; the major water uses are supplied from the Columbia River or Yakima River systems. Note that the first water level measurement from well 8N/29E-15Q01 (1978), which is completed across both the Saddle Mountains and Wanapum Aquifers, is roughly 60 feet lower than subsequent levels (Figure 11). It is uncertain whether this represents a pumping level, or whether the rise is attributable to return flow recharge reaching the Saddle Mountains Aquifer. Of the multiple wells visited in April 2005 for this study, water level measurements could be collected from only 2 wells. Other wells had access for water level sounding, but we could not get the water level indicator past obstructions (e.g., pump wires) in the well.

According to Vaccaro (1999), the Horse Heaven Hills to the west of the project area act as a regional divide to groundwater flow within the Wanapum Basalt Aquifer. This would suggest that regional groundwater flow is to the north, towards the Columbia River. However, this contradicts evidence suggesting that the folds and faults of the Rattlesnake Ridge and Webber Canyon Anticlines represent boundaries to groundwater flow. As discussed in Section 3.3, the pumping test in Richland's Willowbrook well, located just north of a regional thrust fault, indicated the presence of a low-permeability aquifer boundary interpreted to be the thrust fault (Golder Associates 2001a). As described in Section 3.3, there is often sufficient flexure and fracturing of the basalt units within the crests of anticlines (irrespective of thrust fault presence) that they can also restrict lateral groundwater flow.

Figure 12 presents available groundwater elevations for wells completed within the target aquifer, the Priest Rapids Member of the Wanapum Basalt Aquifer. Because of the lack of water level data, the groundwater elevations span the time period 1995 to present. The groundwater elevations are based on ground surface elevations from a Digital Elevation Model (DEM) and static water levels acquired from either the USGS groundwater level monitoring program or the well logs. Table 6 summarizes the static water elevation and well completion data for the wells shown on Figure 12. A range of static water elevations is provided on Figure 12 for wells with poor location accuracies (quarter-quarter section resolution). These static water elevation ranges were determined from the range in land surface elevations for a particular quarter-quarter section location.

In general, regional groundwater flow within the Columbia River Basalt Group is expected toward major surface water bodies, away from anticlinal axes and in the direction of regional geologic dip (Steinkampf 1989). Limited groundwater quality data in the project area generally support these assumptions. Groundwater composition near the Rattlesnake Ridge Anticline complex is generally of the calcium-magnesium sulfate-chloride or calcium-magnesium-sodium bicarbonate type, suggesting recent recharge, while groundwater away from the fold belt is of the sodium bicarbonate type, suggesting longer residence times within the flow system.

Groundwater flow directions and gradients for the project aquifer can be estimated based on the spot groundwater elevations and the assumption that the faults/folds of the Rattlesnake Ridge and Webber Canyon Anticline complexes represent boundaries to lateral groundwater flow. Because of the limited number of target aquifer wells with static water level data, groundwater flow directions were determined based on triangulation techniques using two sets of wells: 8N/28E-3R01, 8N/28E-13R01, 8N/29E-17R02 toward the center of the area between the linear fault/fold alignments; and 8N/28E-3R01 8N/28E-23D02, 8N/29E-17R02 which ties in the flank of the southern (Webber Canyon) faulted anticline. For wells with a range of static water elevations (due to inaccuracy of well locations), the average groundwater elevation was used in this preliminary calculation of the hydraulic gradient.

Triangulation with the first set of wells produced a groundwater flow direction to the southeast, approximately parallel to the regional anticlinal structures and towards the Columbia River at a gradient of 0.0013 feet/foot (13-foot drop for 1,000 feet horizontally). Triangulation with the second set of wells produced a groundwater flow direction to the north, away from the Webber Canyon faulted anticline, with a much higher gradient of 0.015 (15-foot drop for 100 feet horizontally). These groundwater flow directions support the assumption that groundwater flows away from the anticlinal crests and towards major surface water bodies. The higher groundwater gradient calculated from the second set of wells is consistent with the assumption that groundwater gradients are higher along the flanks of anticlines where the inclination of the basalt layers is higher. Vaccaro (1999) stated that relatively large groundwater gradients (between 0.019 and 0.057) have been observed on the flanks of numerous anticlines, including the Horse Heaven and Rattlesnake Hills.

The hydraulic gradient can be used to determine an average groundwater flow velocity by applying Darcy's Law of the form (Fetter 1994):

$$V_x = -\frac{Kdh}{n_e dl}$$

where:

$v_x$ is the average linear groundwater velocity (ft/day), K is the hydraulic conductivity (ft/day), dh/dl is the hydraulic gradient, and $n_e$ is the effective porosity. In the calculation of the groundwater flow velocity, a hydraulic conductivity of 36 ft/day was used based on the Willowbrook well pumping test, and an effective porosity of 0.04 was used based on Hansen et al. (1994). Because a groundwater flow direction and gradient triangulated from the first set of wells is most likely representative of groundwater flow in the ASR target area (at distance from anticlinal structure and faults), a gradient of 0.0013 was used to produce an average groundwater flow velocity of approximately 1.2 ft/day, or 430 ft/year.

## 3.5 Recoverability of Stored Water

As described above, the relatively sparse water level data set for the target aquifer results in considerable uncertainty regarding groundwater flow direction and velocity in the ASR target area. Flow direction and velocity can be important considerations in how an ASR system is operated to maximize recovery of the water stored. Recoverability (expressed as the percent of the water volume stored that can subsequently be recovered) will typically decrease in aquifers with a higher ambient (natural) groundwater velocity. This occurs because the volume of recharge water stored (the "recharge bulb") flows with the natural groundwater velocity away from the ASR well, potentially to a point that pumping of the ASR well can no longer capture it (draw it back against the ambient flow velocity). Optimizing recovery of the stored water can be particularly important where high-quality source water is being stored in an aquifer with lower quality water. While the available data suggest groundwater quality in the target area is decent, we expect it to not be as good a quality as the City's treated water to be stored.

Based on the geologic structure and aquifer parameters in the previous sections, it is possible to use relatively simple numerical groundwater flow modeling to illustrate recoverability of the recharge bulb under various ASR operational scenarios and for a range of ambient groundwater velocities as currently understood from the available information. The main operational components to be examined are recharge (injection) and recovery (pumping) rates and durations, as well as duration of storage between recharge and recovery phases. It is important to stress that this preliminary modeling is essentially conceptual, to schematically illustrate operational concepts that can improve recoverability of the recharge bulb. Pilot testing would be needed to better quantify aquifer parameters and water quality in a specific location, as well as recharge and recovery rates from an actual ASR well. This information would refine the degree of recoverability relative to that indicated from this preliminary modeling. This modeling also assumes no mixing between recharge water and the ambient groundwater. Such mixing would occur along the fringe of the recharge bulb, reducing the volume of 'pure' recharge water that could be recovered relative to these modeling simulations. The degree of water quality mixing, and whether a mixed water quality would be unsuitable for the City's use, would also need to be determined through pilot testing.

For the purposes of this preliminary modeling, we assumed a properly constructed ASR well in the target aquifer could recharge and pump sustainably at rates of 800 to 1,200 gpm (refer to Section 3.3). Modeling of operational scenarios was performed assuming an ambient groundwater velocity of 430 ft/year, which assumes a horizontal hydraulic gradient of 0.0013 ft/ft in the ASR target area (Section 3.4). While a variety of operational scenarios were modeled for this study, the following three are discussed here for illustration purposes:

1. Recharge 800 gpm for 90 days, then immediately recover 1,200 gpm for 60 days. That is, recharge 318 acre-feet (AF) of water, and recover 318 AF;
2. Recharge 1,200 gpm for 60 days, then immediately recover 1,200 gpm for 60 days. Recharge 318 AF of water, and recover 318 AF;
3. Recharge 800 gpm for 90 days, store that water for 90 days, then recover 1,200 gpm for 60 days. Recharge 318AF of water, and then recover 318 AF after a 3-month storage period in the aquifer.

Results of the modeling for these three assumed operational scenarios are summarized in Table 7, and the recoverabilities for each are illustrated schematically on Figure 13. On Figure 13, the areal extent of the recharge bulb (injection) is shown in blue, while the areal extent of the recovery capture zone (pumping) is shown in red (plus purple). A capture zone is that portion of the aquifer that contributes flow to a well while pumping. It is not the same as the radius of drawdown around a well. The width and downgradient extent of a capture zone is directly dependent on the ambient groundwater velocity; a higher ambient groundwater velocity results in a smaller capture zone. The upgradient extent of the capture zone is dependent on the pumping duration (longer duration = longer capture zone). The downgradient extent of the pumping capture zone is fixed based on pumping rate, and that downgradient extent provides a limit to the quantity of recharge water that can be recovered.

In Figure 13, the areal extent of the capture zone overlapping the recharge bulb is shown in purple. In other words, the purple represents that portion of the recharge bulb that is recovered in the ASR scenario. The area of the recharge bulb that is not recovered shows up as blue (higher quality water). The area showing up as red is ambient groundwater (presumed lower quality) that is recovered in that operational scenario. The operational goal for ASR is to maximize recovery of the high quality recharge water, which equates to maximizing the area shown as purple while minimizing areas shown as red and blue on Figure 13.

In Scenario 1 (recharge 800 gpm for 90 days; recover 1200 gpm for 60 days), an estimated 94 percent of the recharge water (299 acre-feet) is recovered according to this modeling. Under this scenario, 19 acre-feet of the recharge water are unrecovered (lost); instead 19 acre-feet of ambient groundwater are recovered (Figure 13; Table 7). Under actual operation, recovery pumping likely would be stopped once poorer-quality water started to be recovered (determined by water quality monitoring).

In Scenario 2, the same volumes are recharged and recovered as in Scenario 1 but the recharge rate is increased to 1200 gpm and the duration decreased to 60 days. The intent of the higher recharge rate is to ‘push’ additional recharge water further upgradient of the ASR well, thus increasing the opportunity to recover it before it moves beyond the downgradient limit of the ASR well’s capture zone. In this scenario, the modeled recoverability increases only very slightly (95 percent) relative to Scenario 1 (Figure 13; Table 7). However, it is uncertain whether a 1200 gpm recharge rate could be sustained in an ASR well. Well screens in ASR wells are the same as those in typical production (pumping) wells, designed to facilitate water entering not exiting them; therefore the well screens tend to be more efficient in recovery (extraction) mode than recharge (injection) mode. In addition, injection is often conducted through the pump column in the line-shaft turbine pump used to pump from the well. Greater head loss can occur when injecting water through the pump bowls than when extracting through them – further reducing efficiency of an ASR well in recharge mode relative to recovery mode. Because it is questionable whether a 1200 gpm recharge rate could be achieved in an ASR well that can pump 1200 gpm, the remaining operational scenarios assume an 800 gpm recharge rate.

Scenario 3 is the same as Scenario 1, except that a 90-day storage period occurs between the recharge and recovery phases. As discussed above, we expect that additional peaking supply provided by an ASR well would be of most use to the City in July and August. Seasonal demand ramps up quickly in the 2-3 months preceding July, so there may not be surplus production capacity in these months to store (Figure 8). Therefore, we expect that some period of storage would likely be needed between recharge and recovery phases in most years. Scenario 3 could represent recharge January through March, storage April through June, and recovery for use in July and August. This assumed 90-day storage period reduces recoverability (89 percent) relative to Scenario 1 with no storage (94 percent). The storage period provides additional time for the recharge bulb to be transported downgradient, thus reducing the volume of water that is recoverable from the ASR well. However, under this simplified modeling, this reduced recoverability is small, and we expect that the loss of recharge water would need to be factored into the economics of a prospective ASR program since some storage period would likely be necessary.

In summary, for a given ambient groundwater velocity in the storage aquifer, this preliminary modeling indicates that:

- Recharge water recoverability decreases with an increase in recharge duration;
- Recoverability increases with an increase in recharge rate; and
- Recoverability decreases with the addition of any storage period prior to recovery.

Recharge water recoverability also generally decreases with higher ambient groundwater velocity of the storage aquifer, as discussed in the next section.

### *3.5.1 Modeling of Higher Ambient Groundwater Velocity Conditions*

Due to uncertainty regarding hydraulic gradient across the target area, operational Scenario 3 was also modeled assuming a 0.015 ft/ft gradient, which is the maximum observed in the project area (flank of anticline) as discussed in Section 3.4. We expect that the resulting groundwater velocity (4,900 ft/year, maintaining the 36 ft/day hydraulic conductivity assumed above) is unreasonably high, and that areas of high gradient would likely occur where hydraulic conductivity is correspondingly lower (maintaining lower velocity). Nonetheless, this simulation was performed (Scenario 4) to illustrate how ASR operation and recharge water recoverability may change under a higher groundwater velocity scenario that could occur depending on specific location for a prospective ASR well(s). Comparison of recoverability between the two groundwater velocity scenarios (Scenarios 3 and 4) demonstrates the importance of characterizing groundwater flow direction and velocity in the target aquifer as part of a pilot testing program.

At this very high groundwater velocity, the recharged water flows downgradient quickly, resulting in zero recoverability when a 90-day storage period is included (Figure 14; Table 7). In such a case, one operational scenario to dramatically improve recoverability would be completion of a second recovery well downgradient of the first ASR well. The second well would not be used for recharge, but would be positioned to maximize recovery of the migrating recharge bulb. Likewise, the original ASR well is used only for recharge in this Scenario 5. This dual-well approach can provide excellent recoverability (94 percent) as illustrated schematically on Figure 14. With greater refinement of the model grid to allow more precise well placement, it should be possible to simulate even a higher percentage of recoverability.. However, to be successful, and potentially worth the additional cost, this approach would require an accurate knowledge of groundwater velocity and flow direction in order to position the second well for optimal recovery efficiency. We expect that such additional well placement would be constrained by property ownership and other logistical considerations.

## 3.6 Anticipated Changes to Groundwater System from ASR Project

The largest anticipated changes to the groundwater system from an ASR project would be changes in head (drawdown/mounding) and changes in local groundwater flow direction and velocity around the ASR well. Figures 15 and 16 show the modeled mounding/drawdown and groundwater flow pathlines at the end of the 90-day aquifer recharge period and the end of the 60-day recovery period, respectively, for Scenario 3 described above.

During the 90-day aquifer recharge period, the maximum mounding in the aquifer immediately outside the ASR well location is estimated from the model as 26 feet. Note that, in Figure 15, the mounding contours are labeled with negative numbers, representing negative drawdown (head buildup) as produced by the numerical model. A modeled 26-foot change in head at the well location is very close to the 25-foot change in head calculated in Section 3.3.4. However, the equation applied in Section 3.3.4 assumed an aquifer of infinite areal extent, whereas the numerical model assumed a long narrow aquifer system bounded by low permeability boundaries on the north and south. The model indicates that the areal extent of mounding is a maximum of 5.8 miles from the ASR well, in the downgradient direction (Figure 15).

The modeled groundwater flow pathlines demonstrate that groundwater flow directions are affected in proximity to the ASR well, because of the radial flow away from it. The extent of flow direction perturbation is relatively localized, with flow generally resuming the regional flow direction within about 2 miles downgradient of the ASR well. Because the recharge mounding increases the hydraulic gradient, groundwater velocities are increased relative to ambient conditions across the entire downgradient extent of mounding (the pathlines on Figure 15 do not show changes in flow velocity).

During the 60-day recovery period of Scenario 3, the maximum drawdown in the aquifer at the ASR well location is 39 feet (Figure 16). A modeled 39-foot drawdown is close to a 36-foot change in head calculated using the equation in Section 3.3.4. Changes in groundwater flow direction remain relatively localized around the ASR well, with radial flow converging to, rather than diverging from, the ASR well. Such changes occur around any production well. Groundwater flow directions resume the regional direction within 2 to 3 miles downgradient of the ASR well. On Figure 16, the downgradient extent of the ASR well’s recovery capture zone occurs in the area between where flow arrows are directed back toward the ASR well and where they are directed downgradient (in the area of the 17-foot drawdown contour). This relatively short distance, roughly one-half mile, helps illustrate why recharge water recoverability can be limited and thus why a thorough understanding of groundwater flow direction and velocity is important to designing an ASR program that can achieve economically viable recoverability.

## 3.7 Estimated Area Potentially Affected by ASR Project

The current conceptual model assumes the target aquifer is bounded laterally by the Rattlesnake Ridge and Webber Canyon faulted fold complexes. Because of this relatively complex aquifer geometry, the numerical modeling described above, with aquifer boundary conditions simulating these geologic structures, should provide a reasonable estimate of the area potentially affected by the ASR project.

Based on the modeling of recharge and recovery for assumed operational Scenario 3 (Figures 15 and 16), the estimated area affected by the ASR project is presented on Figure 17. This area is based on the 5-foot drawdown contour from the 60-day recovery period (Figure 16). The 5-foot drawdown contour from the assumed recovery period (1200 gpm) covers a larger extent than the 5-foot mounding contour from the recharge period (800 gpm) and thus provides the current estimated maximum area affected by the project. A 5-foot change in head was used as the limit to the area because seasonal water level changes of 5 feet are common. A 5-foot and 10-foot change in groundwater levels was observed in wells 8N/28E-03J01 and 8N/28E-23C02, respectively, between September 2001 and March 2002 (Figure 11). Because the Rattlesnake Ridge and Webber Canyon faulted fold complexes are believed to act as boundaries to lateral groundwater flow, the estimated area affected would be bound by these features to the north and south.

## 3.8 Location of Wells or other Sources of Groundwater within the Area Affected by the ASR Project

Figure 17 shows the location of wells completed within the project area, and those within the area potentially affected by an ASR project, according to the Ecology well log database as of February 2005. The figure distinguishes wells completed at depths of greater than 500 feet (yellow) from wells completed at depths of less than 500 feet (blue). In the vicinity of the ASR target area, wells deeper than 500 feet are generally completed within the Wanapum Formation. As discussed in Section 3.3, the Mabton Interbed vertically confines the Wanapum Formation from the overlying Saddle Mountains Basalt Aquifer and younger unconsolidated materials, and the Mabton is believed to be an effective regional aquitard. Therefore, wells completed above the Wanapum Formation (less than 500 ft) are unlikely to be affected by the ASR project. That constitutes the majority of the wells in the project area (Figure 17).

Based on the numerical modeling, wells within or near the ASR target area, completed in the target aquifer, could see short-term mounding in the range of about 8 to 15 feet and short-term drawdown in the range of about 12 to 18 feet. The majority of the deeper wells in the affected area are west of Coyote Canyon; these wells are at greater distance from the ASR target area and would see correspondingly smaller water level changes. Mounding would be expected to have no adverse impact on surrounding wells. Drawdown could, but only if it required significant modification (pump lowering, well deepening, etc.) to allow the well to be used. Measuring potential water level changes in surrounding wells would be an important element of an ASR pilot test (Section 5). Unlike the other numerous production wells in the affected area, an ASR well would remove groundwater that had been stored in the target aquifer, rather than extracting natural recharge from storage.

## 3.9 Location of Natural Hazards, Surface Waters, and Springs Potentially Affected by ASR Project

WAC 173-157-120 specifies identification of natural hazards, surface waters, and springs potentially affected by the ASR project as part of the Hydrogeologic Conceptual Model. These same items are also required to be identified and evaluated as part of the Environmental Assessment (WAC 173-157-150). Therefore, the Environmental Assessment (Section 4) of this report includes the identification and evaluation of these items.

## 3.10 Chemical/Physical Composition of Source Water and Compatibility with Ambient Groundwater

As discussed in Section 3.3.5, the source water for a prospective City of Kennewick ASR program would be a mixture of both groundwater (Ranney Collectors #4 and #5) and Columbia River water (via the Water Treatment Plant). The Ranney Collectors have a total combined capacity of 14 MGD and are typically used as a water source year-round. Water from the Ranney Collectors is chlorinated prior to distribution. The Water Treatment Plant has a current capacity of 7.5 MGD; however, the plant is currently being upgraded to a 15 MGD capacity. Water from the Water Treatment Plant is treated by flocculation, sedimentation, and membrane filtration. The Water Treatment plant is generally in operation from mid-April to mid-November and during this period the water supplied to the City's customers is typically a mixture of all three sources.

Table 5 presents historical (1996 - 2000) water quality data for Ranney Collector #4 and #5, as well as the water treatment plant (Golder Associates 2001a). Aspect Consulting also collected a water quality sample from the city water distribution system at 28th and Irving Reservoir, located near the ASR target area (Figure 1), in April 2005. This sampling documents water quality data of the prospective ASR source water at a time when the source water is a mixture of both groundwater and surface water. Table 5 demonstrates that the water from 28th and Irving Reservoir typically has constituent concentrations within the ranges observed from the historical water quality data for either the Ranney Collectors or the Water Treatment Plant. Overall, the April 2005 constituent concentrations in water from 28th and Irving Reservoir appear to more closely represent water from Ranney Collector #4.

Based on the April 2005 sampling of the composite water in the distribution system, all constituent concentrations are below health-based drinking water standards (primary MCLs), which is consistent with historical data from the individual sources (Table 5). The April 2005 sodium concentration in the source water (24 mg/L) is slightly above the federal guideline of 20 mg/L, set to protect persons requiring low sodium in their diet. Nitrate was present at a concentration of 2.9 mg/L, well below the 10 mg/L MCL. The water temperature was approximately 58 ºF, with a pH near neutral at 7.3. The water is oxygen-rich, with a DO of 6.8 mg/L and a redox potential of 740 mv. Total dissolved solids (TDS), total suspended solids (TSS) and turbidity are all relatively low; with values of 291 mg/L, less than 4 mg/L, and 0.87 NTU, respectively.

Byproducts from chlorine disinfection can include trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform) and haloacetic acids (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromoacetic acid, dibromoacetic acid). Trihalomethanes (THMs) can form from reaction of chlorine with organic matter in the water; high bromide levels in water can also contribute to THM formation. THMs and HAAs are potentially carcinogenic and EPA has established primary MCLs for total THMs and total HAAs of 80 µg/L and 60 µg/L, respectively.

The total haloacetic acid concentration in the sample of 28th and Irving Reservoir water was 8.2 µg/L, well below the 60 µg/L standard. Detected concentrations of the THMs chloroform, bromodichloromethane, dibromochloromethane, and bromoform were 5.06, 5.68, 6.87 and 2.56 µg/L, respectively. The calculated total THM concentration for the source water is thus 20 µg/L, well below the 80 ug/L MCL. However, the State of Washington Groundwater Quality Standards include criteria of 7 µg/L for chloroform, 0.3 µg/L for bromodichloromethane, and 5.0 µg/L for bromoform (WAC 173-200-040). Of these, the detected concentration of 5.68 µg/L bromodichloromethane in the prospective ASR source water is above the stringent groundwater quality standard of 0.3 µg/L.

These disinfection byproduct data are consistent with data from each of the four quarterly monitoring events in 2004 provided by the City, all of which confirm total THM and total HAA concentrations well below respective MCLs (John Griffin, personal communication, March 9, 2005).

Concentrations of volatile organic compounds (VOCs) and synthetic organic compounds (SOCs) were not measured for this study because they are presumed to be non-detect in both the source water and target aquifer. Data from City of Kennewick's routine monitoring confirm the consistent absence of VOCs and SOCs in the prospective source water (John Griffin, personal communication, March 24, 2005).

### 3.10.1 Comparison of Source Water and Groundwater Quality

The quality of source water from 28th and Irving Reservoir was compared to the quality of groundwater in the ASR target area. As described in Section 3.3.6, a water quality sample was collected in April 2005 from the Brinkley domestic well (8N/29E-17E01), located within the ASR target area and screened primarily in the target aquifer. The water from the Brinkley well is of a similar type (calcium-magnesium sodium-bicarbonate) as the water from 28th and Irving Reservoir (Figure 10). The groundwater temperature and pH are slightly higher than the source water at 63 °F and 7.7, respectively. Based on the field measurements, the groundwater and source water are both aerobic (DO above 6 mg/L); the groundwater had a much lower redox potential (Eh) than the source water (185 vs. 740 mv) but both values indicate oxidizing conditions. The groundwater specific conductivity (454 mg/L), turbidity (0.95 NTU), color (10) and TSS (less than 4 mg/L) are all relatively close (less than 10 percent difference) to the source water parameters. Notably, concentrations of silica (103 mg/L) and fluoride (0.414 mg/L) were considerably higher in the Brinkley well than the source water (273 percent and 136 percent higher, respectively). Results of the comparison between the source water and ambient groundwater are summarized in Table 5.

High concentrations of dissolved silica are likely observed in the Brinkley well, in addition to other wells in the project area, due to the dissolution of basaltic glass within the basalt aquifers. The high concentrations of dissolved silica in the groundwater may cause dissolved silica to precipitate as amorphous aluminosilicate (Steinkampf 1996). However, because it can be assumed that the dissolved silica in the groundwater is already at equilibrium, amorphous aluminosilicate would only precipitate if additional dissolved aluminum were added to the groundwater system. The source water from 28th and Irving Reservoir had no detectable dissolved aluminum (less than 0.01 mg/L), so it appears unlikely that amorphous aluminosilicate would precipitate as a result of the addition of source water to the groundwater system.

Based on the April 2005 field measurements, the ambient groundwater and source water are aerobic. However, because the Brinkley well also taps part of the Saddle Mountains Basalt (typically higher DO than Wanapum) it is uncertain the degree to which that may influence the water quality readings. Introducing oxygenated source water into an anoxic aquifer could have a large effect on the solubility and mobility of many metals within the groundwater system (Drever 1982). The Brinkley well has relatively low concentrations of dissolved metals. However, other wells in the project area (Raine 8N/29E-17R02 and Gilliam 8N/29E-17H01) have relatively high concentrations of dissolved iron, which is typical of reducing (anoxic) conditions. Depending on conditions at the site of an ASR well, adding oxidized recharge water to such an aquifer could oxidize dissolved ferrous iron causing precipitation of ferric oxyhydroxides (Steinkampf 1996). Iron precipitation as well as growth of iron bacteria could present a clogging problem for an ASR well. More detailed geochemical evaluation would be warranted using data collected from an ASR pilot test well.

### *3.10.2 Water Quality as an Operational Consideration*

The ambient groundwater quality at a prospective target ASR location will be an important consideration to be evaluated as part of a potential ASR pilot test. Because the conceptual ASR plan is to store the same potable water served to the City’s customers (meeting drinking water standards), the quality of the stored water would be excellent. To the extent the ambient groundwater quality in the storage aquifer does not meet drinking water standards or other aesthetic goals (e.g., water temperature, dissolved gasses, or iron), water quality mixing of the excellent-quality recharge water with the lower-quality ambient groundwater in the aquifer may limit the volume of stored water that can be recovered without sacrificing quality. If the quality of the recharge water is better than the ambient groundwater quality, successive ASR cycles may gradually improve groundwater quality in the target aquifer over the long term.

If the water to be stored has constituents present at concentrations above that of the ambient groundwater (e.g., disinfection byproducts), the storage could be interpreted to violate the antidegradation provision of the state’s Groundwater Quality Standards (WAC 173-200-30). However, since the prospective source water meets drinking water standards, beneficial use of the groundwater would not be degraded, thus presumably meeting the intent of the Ground Water Quality Standards. Furthermore, it might be argued that an ASR program would be in the overriding public interest, including secondary benefits to Columbia River instream resources as mentioned above; public interest is another consideration in evaluating compliance with the state antidegradation policy. In any event, we expect that the antidegradation policy would be a regulatory issue of importance in evaluating the viability of an ASR program for the City.

With respect to disinfection byproducts, case study data summarized in Pyne (1995) and St. Johns River Water Management District and Pyne (2004) indicate that concentrations of THMs and HAAs decline relatively quickly when source water containing them is stored in the subsurface. The data generally suggest that THMs and HAAs are degraded biologically in a matter of weeks under anoxic groundwater conditions. The USGS documented little biological degradation of THMs within an aerobic shallow unconfined sand and gravel aquifer (Fram, et al. 2003). One concern consistent in the studies is that residual chlorine in the source water (required by state regulation for public water systems) can react with organic matter in the aquifer with the potential to generate THMs. Whether the THMs generated then degrade appears to be a consequence of the groundwater redox conditions in the aquifer, with degradation occurring preferentially in anoxic aquifers.

The City of Yakima's ASR pilot testing using treated potable water documented initial increases in THM and HAA concentrations in the storage aquifer, and a corresponding decrease in residual chlorine, throughout the first half of the 55-day storage period between recharge and recovery. The increases were attributed to reaction of residual chlorine with naturally occurring organic matter in the groundwater. Concentrations of THMs and HAAs generally declined in the latter part of the storage period, and then declined rapidly in the recovered water during the recovery period. The declining concentrations were attributed to a combination of degradation and dilution/dispersion. THM and HAA concentrations remained well below drinking water criteria throughout the test (Golder Associates 2001b).

# 4 Environmental Assessment

## 4.1 Description of Environment within ASR Project Area

As discussed in Section 3.1, the ASR target area is within the southwest portion of the City of Kennewick water service area, near a 1000-foot high ridgeline which comprises part of “The Rattles” (Figure 1). Figure 18 presents the land cover for the project area, taken from the most recent U.S. National Land Cover Data (NLCD) map coverage available for WRIA 31 (1992 Landsat images). Within the vicinity of the ASR target area, the predominant land cover is shrubland, with relatively small patchy areas of cultivated lands (irrigated). Less than 1 mile to the northeast of the ASR target area is the City of Kennewick urban area, which consists primarily of developed lands, with small interspersed patches of grasslands/shrublands, and irrigated agricultural areas. To the south of the ASR target area, on the plateau of the Horse Heaven Hills, is a vast area of cultivated lands (predominantly dryland farming and smaller irrigated areas), with only small areas of grasslands or shrubland within the drainages.

The major surface water drainages within the project area include the Columbia River roughly 4 miles to the northeast, as well as Badger, Coyote, Amon, and Zintel Canyons (Figure 18). Additional discussion of these drainages, and floodplains and wetlands, is included in Section 4.2.2. The Columbia River, as well as the Amon and Zintel Canyon Wasteways have flow gaging stations, at which streamflows have been monitored over certain periods of time. The hydrographs for the Columbia River, near McNary Dam and Pasco (Figure 9), are discussed in Section 3.3.5. Figure 19 provides flow hydrographs for the Zintel and Amon Canyon Wasteways for the time period March 1986 through April 1987. The hydrographs show relatively low flows, less than 15 cfs for Amon Wasteway and less than 5 cfs for Zintel Wasteway, between the middle of October and the middle of March, with relatively higher and more variable flows between the middle of March and the middle of October. Amon Wasteway carries flows typically between 20 and 80 cfs, with peaks to 140 cfs, in this period. The relatively higher and more variable flows between March and October are representative of irrigation runoff and drainage/overflow from irrigation canals.

In addition to land cover, Figure 18 also depicts locations of confirmed and suspected contaminated sites and leaking underground storage tanks within the project area, as acquired from the Department of Ecology Toxics Cleanup Program Cleanup Site Information. The nearest sites are more than a mile east/northeast of the ASR target area, with the majority of sites more than 5 miles from it. For completeness, tables containing summary information on the various sites, as referenced by the facility site ID, can be found in Appendix A. The confirmed and suspected contaminated sites and leaking underground storage tank sites can include soil, groundwater, and/or surface water contamination. As will be discussed in greater detail in the following sections, it is unlikely that contaminated sites will be affected by, or affect, an ASR project with a target aquifer in the Wanapum Formation. As discussed in Section 3, the target aquifer is present at depths greater than about 500 feet and does not outcrop anywhere within the project area. The target aquifer is also overlain by the Mabton Interbed, which acts as a regionally extensive vertically confining unit. The vertical confinement of the target aquifer provides hydraulic isolation from surface waters and shallow aquifers in the area.

## 4.2 Potential for Adverse Environmental Impacts within ASR Project Area

### *4.2.1 Natural Hazards Potentially Affected by ASR Project*

Potential natural hazards identified within the ASR project area can include slope stability and erosion, the creation of springs, the presence of floodplains, the presence of ground deformation/subsidence, and the presence of faults. Figure 20 presents a map depicting areas of steep slopes (greater than 15 percent), areas where the soils have been identified as water erosion hazards or otherwise “generally hazardous”. A GIS coverage of geologically hazardous areas was received from the City. Areas characterized as slopes greater than 15 percent were then refined using a Digital Elevation Model (DEM) for the Kennewick area. As show on Figure 20, a large proportion of the slopes are greater than 15 percent within the project area. The Soil Conservation Service (SCS) categorizes soils on steep slopes as either severely eroded and/or a water erosion hazard (15-30 percent slopes) or severe to very severe water erosion hazard (30-65 percent slopes). Adjacent the AST target area, there are numerous areas of severely eroded and/or water erosion hazard (15-30 percent slopes), including Amon, Coyote, and Zintel Canyon drainages and tributaries, as well as near the Rattlesnake Ridge Anticlinal ridge north of the ASR target area. Areas of severe to very severe water erosion hazard (30-65 percent slopes) also include Amon, Coyote and Zintel Canyons, as well as the north flanks of the Rattlesnake Ridge Anticlinal ridge. Figure 20 also presents areas of “generally hazardous soils” (0-30 percent slopes). These areas are present within Coyote and Zintel Canyons, as well as on top of the Rattlesnake Ridge Anticlinal ridge.

The areas of defined geologically hazardous soils may pose a problem for where ASR well(s) can be sited. We understand that the City is in process of defining a critical area ordinance, and we expect slopes/soils would be addressed through a SEPA checklist when construction is proposed. Because the target aquifer is at depths greater than 500 feet, and vertically confined by an effective aquitard, the areas of geologically hazardous soils should not be affected by groundwater mounding/drawdown from an ASR project.

The areas where seeps (springs) are most likely to occur as a result of an ASR project are those in which the basalts of the target aquifer are exposed at the surface (Figure 3). In the area surrounding the ASR target area, only the overlying Saddle Mountains Basalt is exposed at ground surface, even in deeper drainages. The target aquifer, the Priest Rapids member of the Wanapum Basalt, does not outcrop anywhere in the project vicinity (not within the area depicted on Figure 3). The cross sections (e.g., Figure 5) indicate that the target aquifer is several hundred feet below the bottoms of these drainages. Because the relatively thick Mabton interbed separates the target aquifer from the shallower Saddle Mountain Basalt in the project area, it is unlikely for seeps to be created at locations where the Saddle Mountains Formation is exposed at the surface as a result of water artificially recharged to the target aquifer. Therefore, there is negligible risk of creating seeps as a result of an ASR project in the target area.

Figure 20 also depicts the Federal Emergency Management Agency (FEMA) 100-year floodplains defined within the project area. The main drainages within the project area with defined 100-year floodplains are Zintel Canyon and the Columbia River shoreline. Zintel Canyon is the closest floodplain at a distance of nearly 2.5 miles. As stated above, the target aquifer is hydraulically isolated from surface features including floodplains, and thus should not be affected by an ASR project in the target area. A new ASR well(s) would be sited outside of a 100-year floodplain as required for any water supply well under state regulation (WAC 173-160-171).

Ground deformation/subsidence should not be a problem within the ASR project area because the target aquifer is composed of indurated basalt and should not be susceptible to deformation/subsidence. Interbeds are sedimentary material but are likewise indurated with limited potential for consolidation. Furthermore, the cross-sections (Figures 4 and 5) demonstrate that the surficial unconsolidated overburden is relatively thin in the ASR project area (< 85 feet) and none of the wells completed in the Wanapum Formation have static water levels within the overburden. We expect no change in saturation level of the overburden as a result of an ASR program in the target aquifer, thus no potential for ground deformation in this material.

As described in Section 3, there are several thrust faults in the ASR project area. A thrust fault associated with the Rattlesnake Ridge Anticline complex is located more than a mile north of the ASR target area and the Webber Canyon thrust fault is more than 2 miles south of the target area. We are aware of no evidence that these faults are active seismic hazards. Even if they are, an ASR project is at no greater risk, nor are there are any greater implications if a seismic event does occur, than for a conventional production well.

### *4.2.2 Surface Waters Potentially Affected by ASR Project*

Figure 20 also presents the location of rivers, streams, irrigation canals, and wetlands within the ASR project area. The target ASR area is approximately 4 miles south of the Columbia River (Lake Wallula).

There are numerous, unnamed, intermittent streams present within the vicinity of the ASR target area, but a majority of the streams drain into either Badger, Coyote, Amon, or Zintel Canyons. Amon Canyon and Wasteway is the closest major drainage to the preferred ASR site (within approximately 2,500 feet). An evaluation of Amon Wasteway, which discharges to the Columbia River, concluded it did not represent critical habitat for steelhead and rainbow trout because of poor water quality and rapid fluctuations in flow (S.P. Cramer and Associates 2005). The Coyote Canyon and Badger Canyon drainages are located at greater distances to the west of the target ASR location and the Zintel Canyon drainage is located east of it. These canyons will constrain the siting of ASR well site(s) within the target area.

The major canals and laterals in the project area include the AP Canal, AP Lateral, Division Four Canal, Highland Feeder Canal, Highlift Canal, Kennewick Main Canal, West Badger Lateral, East Badger Lateral, and Columbia Canal (Figure 20). The AP

Canal is located closest to the ASR target area (within approximately 1,500 feet), extending east-west along the southern boundary of it. The AP Lateral, Division Four Canal, and Highland Feeder Canal are within approximately 1 mile of the target area.

There are numerous National Wetland Inventory (NWI) wetland areas associated with the rivers, streams, and canals within the project area. The largest wetland areas are within Badger Canyon and Amon Wasteway, as well as within Zintel Canyon (Figure 20). There are several smaller wetland areas within roughly 2 miles of the ASR target area: within Sections 6, 7, and 17 of Township 8N, Range 29E.

Based on limited information, there are relatively few natural springs mapped in the project area. Badger Spring in located in the upper drainage of Badger Canyon, Coyote Spring is located in the upper drainage of Coyote Canyon, and an unnamed spring is located in Section 18 of Township 8N, Range 30E (Figure 20).

Because of the depth of the aquifer targeted for ASR, and the hydraulic isolation from shallow aquifers and surface waters afforded by the overlying Mabton Interbed, it is unlikely that any of the various types of surface waters listed above would be affected by an ASR project in the target area. In addition, the faults and folds of the Rattlesnake Ridge Anticline complex to the north, and the Webber Canyon anticline and thrust fault to the south, may laterally confine groundwater in the target aquifer and thus further prevent interaction with surface waters at greater distance from the target location. Based on the current conceptual model of the groundwater flow system, ultimate discharge of any "lost" recharge would be to the Columbia River – back to the source from which it was ultimately derived.

# 5 Project Monitoring Plan (Preliminary Pilot Test Plan)

This section summarizes recommended elements of an ASR pilot test to further evaluate the feasibility of applying ASR as a water supply alternative to help meet City of Kennewick's peak water demands in the future. A target area has been identified for ASR, but a specific ASR well site has not been identified by the City at this time. Consequently, specific details of a pilot testing program can not be defined. However, the elements of an initial testing program would likely be applicable irrespective of well location and it is these elements that are outlined here. We recommend that the City adapt this preliminary plan to actual conditions should they choose to proceed with evaluation of ASR and select an ASR well to test.

## 5.1 Pilot Test Overview

An ASR pilot test involves testing the expected ASR program including water recharge, storage, and recovery. The program should involve baseline hydraulic testing to document baseline well performance for both recharge and recovery; water quality sampling of the recharge water, stored water in the aquifer, and recovered water; water level monitoring of the ASR well and storage aquifer; pressure monitoring of the pump and piping systems to ensure efficient operation; followed by successive cycles of operation under a range of conditions converging on an expected full-scale operational condition. The testing program can start simply, and gradually be adapted and lengthened in duration as testing information is collected and performance evaluated. This preliminary plan outlines an initial test program, which would then be refined for additional testing if the initial results are promising.

## 5.2 Prospective ASR Well and Piping

While the City has considered performing an ASR pilot test in the past, an ASR well site has not been identified at this time. It may be possible to initiate ASR pilot testing using an existing production well in or near the identified ASR target area. This could provide cost savings relative to constructing a new ASR well. However, many existing wells may not be positioned appropriately in terms of location or aquifer, may not be constructed properly, and/or may not be in a condition suitable for ASR purposes. As pointed out in Pyne (1995), pilot testing using unsuitable existing wells can lead to an incorrect conclusion that an ASR program is not worthwhile, when, in fact, properly constructed facilities would have led to a different conclusion. Large-capacity production wells that are not being used, and thus potentially available for pilot testing, are often not used for a reason (e.g., well deterioration).

If the City obtains permission to pilot test an existing production well screened in the target aquifer, the well’s condition should be verified before proceeding with testing. This may include video camera logging of the well. If a video log indicates that the well screen is encrusted or otherwise deteriorated, an attempt to rehabilitate it can made through redevelopment. Specific well rehabilitation methods can include some combination of physical brushing, surging, acid treatment, jetting, overpumping, etc., depending on specific cause of the deterioration. In all cases, care must be taken to identify and, if possible, correct problems in design or construction of an existing well that could compromise success of an ASR test.

Based on our review of existing well information, we think the existing wells would likely not be suitable for ASR use. Construction of a new ASR well is recommended if economically feasible, rather than pilot testing of an existing well.

Whether the well used for ASR pilot testing is existing or new, the wellhead will need to be plumbed to accommodate both water injection and extraction. The recharge water will come from the same City water distribution pipeline that recovered water would later be returned to for distribution and use, which allows the plumbing for recharge to be at the wellhead. It may be possible to inject water down the discharge piping of a line-shaft turbine pump, if the well is equipped with one. For example, we understand that City of Walla Walla recharges via the turbine pump column in their ASR well. If this is done, the pump motor needs to be equipped with a non-reverse ratchet to prevent backspin of the pump and motor during recharge. An alternative to recharging via the pump column is to install a separate recharge pipe down the well, in addition to the pump discharge pipe. As discussed in Section 3.5, a more efficient recovery of recharge water occurs when the rate of recharge is maximized. Therefore, recharge piping should be sized to accommodate reasonably expected injection flows during the recharge period. It is important that the recharge pipe terminate below the static groundwater level in the well to avoid free cascade of water in the well casing. Such cascading can entrain considerable air in the recharge water, accelerating well clogging through precipitation of oxidized iron or bacterial activity on the well screen. Head loss in the recharge piping can help prevent water cascading in it. Because of the large water level fluctuations within an ASR well, the well casing must be equipped with adequate venting (e.g., air/vacuum release valves).

The recharge piping should include appropriate valving to direct recharge water into the well and discharge water out of the well, without water short-circuiting back down the well or into the distribution system depending on operation mode. The recharge piping should include a valve to control flow rate, pressure valve to measure injection pressures, a flow meter to measure instantaneous recharge rate and cumulative flow volumes, and a sampling port to sample recharge water quality entering the well. These same items should be included on the discharge piping at the well (if separate from recharge) to monitor performance during recovery. Sampling ports should be located at a point of positive pressure in the piping during the respective recharge or recovery cycle. Because recharge and recovery cycles will occur over extended periods, flow meters for recharge and recovery would preferably be connected to a data logger(s)/SCADA system to allow continuous monitoring. The ASR well should likewise be equipped with a pressure transducer/data logger to allow continuous monitoring of water levels in the well. The transducer pressure range, and its depth setting, should be selected based on the assumed range of water levels occurring in the well throughout long-term recharge (mounding) and recovery (drawdown). This would be determined during baseline well testing described below.

The system distribution piping should be equipped with a valve near the ASR well to isolate it from the distribution system, thus allowing operation without interrupting water service in the vicinity. The distribution system near the ASR well should also have a hydrant located as close as practical to the ASR well to allow flushing of the piping (to remove pipe scale and sediment) prior to the start of each recharge cycle. The piping system should also be plumbed to allow pumping of the initial recovery water, or backflush water for well maintenance, to waste if turbid, without it entering the rest of the distribution system. It would also be prudent to be able to monitor pressures in the distribution system near the ASR well during recharge and recovery test phases to ensure no adverse impact to service connections in the vicinity.

A chlorination system would be needed at the ASR well for disinfection of the recovered water prior to its return to the distribution system. Without this, the recovered water from the initial pilot test would need to be pumped to waste.

Pyne (1995) provides a number of construction recommendations for ASR, including use of non-ferrous piping, such as PVC or cement-lined ductile iron pipe, for ASR wellhead piping. This can reduce volumes of rust entering the well during recharge and from the well during initial recovery. Once the ASR well and piping is constructed/retrofitted, it should be disinfected in accordance with DOH and American Water Works Association (AWWA) standards. The ability to maintain “trickle flows” (2-5 gpm) of chlorinated water into the well (via small diameter tubing) can also be useful during periods of neither recharge nor recovery. The objective of the trickle flow is to maintain chlorine residual that limits bacterial growth in the well, thus reducing potential for bacterial plugging. The rate of the trickle flow would be based on the rate of chlorine dissipation in the stagnant well water (typically a day or two). It may be equally effective and easier to periodically shock chlorinate the well during times of inactivity using the same methods as for well disinfection.

Exact layout of system piping, valving, and metering would be dictated based on the actual ASR well and pump configuration.

## 5.3 Source Water

As described above, the source water for an ASR pilot test would be the same as that planned for full-scale ASR operation: the water in the City distribution system closest to the ASR well. This source water meets drinking water standards and would thus not degrade beneficial use of the target storage aquifer. As mentioned above, the distribution system next to the ASR well must always be flushed prior to beginning recharge to limit introduction of suspended solids into the well.

## 5.4 Baseline Well Testing

The first step of the ASR pilot test program would be baseline testing of the ASR well. The objective of this baseline testing is to verify the recharge and pumping capacities of the ASR well/pump/piping combination, both of which are used to define the subsequent pilot testing program. It also documents the well's initial hydraulic performance as measured by specific capacity – flow rate in gpm divided by drawdown/mounding in feet – for both recharge and recovery; this baseline measurement allows evaluation of changes in well performance throughout operation.

The baseline testing would start with a one-day step-rate pumping test, involving pumping at progressively higher rates for relatively short durations to document initial specific capacity and well efficiency of the ASR well under varying pumping conditions. Following the step-pumping test, a one-day step-rate recharge test would be conducted. It would follow the same general process as the step-pumping test, but would involve injecting water into the ASR well at progressively higher rates. From this baseline testing, recharge and recovery rates would be chosen for the balance of the ASR pilot test.

A constant-rate pumping test would not be needed in this baseline testing since aquifer parameters and presence of aquifer boundaries would be determined from data collected during the subsequent long-term recharge and recovery testing cycles.

## 5.5 Recharge, Storage, and Recovery Cycles

Although the duration and flow rates for recharge and recovery cycles in an ASR pilot test would depend on the ASR well capacity and availability of source water, a reasonable starting scenario for the pilot test, after baseline well testing, would be as follows:

- Recharge at a constant rate (to be determined) for 21 days (3 weeks);
- 42-day (6 week) storage period in which no recharge or recovery occurs, other than periodic minimal pumping for water quality sampling; and
- Recover at a constant rate (to be determined) for 28 days (4 weeks). The recovery rate and duration would be determined such that a substantially greater volume of water is recovered than recharged (e.g., 150 percent of recharge volume). This would allow a more complete assessment of mixing in the aquifer by evaluating water quality changes in the recovery water as recovery proceeds.

The above recharge, storage, and recovery time periods would serve as a reasonable starting point for the ASR pilot test. Results from this initial test could then lead to several additional cycles of testing under a range of conditions, with the expectation that the testing would eventually be equivalent to the expected full-scale operational condition. For example, City of Seattle has conducted ASR pilot testing of its Highline wellfield for more than a decade, refining and optimizing operations over that period while putting the recovered water to beneficial use.

## 5.6 Hydraulic Monitoring

The purpose of an ASR pilot test is to collect sufficient information to predict the long-term performance of an ASR program. To that end, extensive hydraulic and water quality monitoring is necessary throughout the testing program. If economically possible, we recommend strong consideration for installation of a monitoring well located within a few hundred feet downgradient of the ASR well – within the expected extent of the recharge bulb - and completed across the same portion of the target aquifer as the ASR well. As illustrated on Figures 4 and 5, there are few existing wells within the ASR target area that are completed solely in the target aquifer. A small-diameter monitoring well positioned and designed specifically for this project would allow much greater confidence in conclusions specific to the target aquifer (hydraulic parameters, water quality, recoverability, etc.) that are drawn from the pilot testing.

Monitoring of neighboring wells is nonetheless important also. As described in Section 4, we expect that the greatest potential for adverse impacts associated with an ASR program in the target aquifer is impact to neighboring wells also tapping the target aquifer. There appears to be a very low probability of adverse impact to surface water, wetlands, slope stability etc. associated with ASR in the target aquifer. Therefore, monitoring of existing neighboring wells, preferably a few of them, provides the empirical information needed to assess potential adverse impacts to neighboring wells (senior water rights) and the environment, and thus determine the need for a project mitigation plan (WAC 173-157-160).

The following hydraulic monitoring elements will be conducted throughout the initial pilot test:

- Monitor water levels continuously (data logger) in the ASR well;
- Monitor barometric pressure continuously (data logger) at the ASR well to allow assessment and correction of water level change due to barometric change;

- Monitor water levels continuously in the target aquifer monitoring well if installed (data logger);
- Monitor water levels in accessible neighboring wells completed within the target aquifer even if also tapping other aquifers. Assuming an ASR well is completed in Priest Rapids Member of the Wanapum within the identified target area, preferred wells for water level monitoring would include one or more of the following wells:
    - Orive (8N/29E-13R02), Hutchison (8N/29E-1301), and Raine (8N/29E-17R02) wells completed in the Priest Rapids;
    - Brinkley domestic well (8N/29E-17E01) completed in the Priest Rapids and overlying Saddle Mountains Aquifer; and
    - Brinkley irrigation well (8N/29E-17Q01) completed in the underlying Roza member of the Wanapum.

  Continuous monitoring data loggers are preferred, but manual measurements with a well sounder would suffice if a well is inaccessible for a downhole transducer. If an existing well is considered important for water level monitoring near the ASR well, it may be worthwhile to pay to retrofit the wellhead to allow installation of a downhole transducer in it during the testing.
- During the initial pilot testing, monitor water levels in one or more readily accessible nearby well completed solely within the Umatilla Member (lowermost portion) of the Saddle Mountains Basalt Aquifer. If a suitable nearby well is available, this type of monitoring would confirm ASR-induced water-level changes in the overlying Saddle Mountains Aquifer system, and thus the degree of vertical confinement of the target aquifer provided by the intervening Mabton interbed (Section 3.3). This information would be used as further support for the environmental assessment – effects on shallower wells and, by extrapolation, surface waters or other surface features. If initial testing confirmed no adverse impacts to water levels in the Saddle Mountains Aquifer, monitoring of the nearby Saddle Mountains well(s) could be discontinued in subsequent testing.
- Recharge and recovery flow rates, both instantaneous (gpm) and cumulative volume (gallons).
- Monitor injection pressure at the ASR wellhead throughout recharge.
- Monitor pressure throughout the City’s distribution system in the vicinity of the ASR well.

Evaluation of the hydraulic monitoring data would include the following:

- Aquifer parameters (transmissivity, storativity) and identification of hydraulic boundaries to the aquifer.
- Magnitude and extent of recharge mounding and its dissipation with time during the storage period.
- Magnitude and extent of drawdown cone during pumping and its dissipation with time and distance.
- Water level changes at neighboring wells in the target aquifer, and, if possible, nearby well(s) in the overlying Saddle Mountains Basalt Aquifer.
- Identification of affected area from ASR.
- Influences of external effects (barometric pressure, pumping of neighboring wells) on aquifer water levels.
- Capture zone extent during recovery.  This likely can not be determined without use of analytical or numerical groundwater modeling tools.
- Baseline well performance (as measured by specific capacity) in both recharge and recovery modes, and changes in that performance following completion of the full ASR cycle conducted in the initial test.
- Distribution system pressure response in the vicinity of the ASR well.

## 5.7 Water Quality Monitoring

Water quality monitoring will be performed in the ASR well throughout the pilot test for the purposes of:

1. Documenting that water being recharged to the target aquifer meets drinking water standards and thus will not degrade beneficial use of the groundwater resource;
2. Document the quality of recovered water to meet the City’s requirements for returning it to the distribution system;
3. Evaluate how mixing of recharge water with ambient groundwater affects recoverability of water meeting drinking water standards and other City requirements, and use this information to adjust duration/rate of recharge and recovery, and duration of storage, to optimize recovery;
4. Document fate of disinfection byproducts (THMs/HAAs) and residual chlorine in the storage aquifer; and
5. Evaluate water quality changes that can affect hydraulic performance of the ASR well.

Table 8 provides a preliminary water quality monitoring schedule (frequency and analytes) for the ASR well during baseline well testing (document ambient groundwater quality), and then during the recharge, storage, and recovery cycles during the initial pilot test. Water quality monitoring for each cycle of the pilot test will be further discussed in the following sections. All water quality analyses will be performed at a laboratory certified by the Washington State Department of Ecology and Department of Health. Because ASR is being considered as an alternate municipal water source for the City, Table 8 includes a comprehensive analyte list to assess compliance with drinking water standards and the antidegradation policy in the initial test. We recommend that the monitoring schedule in Table 8 be adjusted, particularly constituents identified as prospective tracers, following completion of the baseline well testing, when ambient groundwater quality in the storage aquifer can be reliably compared against source water quality. Likewise, we recommend that the monitoring frequency and analytes be refined in subsequent testing cycles, based on results from the initial test, so as to collect those data of greatest value for documenting ASR performance.

### 5.7.1 Prospective Water Quality Tracers

In order to evaluate the recoverability of stored water for various recharge, storage, and recovery cycles during an ASR pilot test, it is recommended that either a natural or artificial tracer be used to estimate the proportion of recharge water in water recovered from the target aquifer (i.e., the degree of mixing between the ambient and recharged groundwater). Depending on the locations of neighboring wells available for pilot test monitoring, use of tracers may also provide empirical information on the areal extent of the recharge “bulb”.

Based on the comparison of April 2005 water quality data for the source water (28th and Irving Reservoir) and ambient groundwater in the ASR target area (well 8N/29E-17E01), prospective tracers to evaluate during an ASR pilot test include: redox potential (Eh), fluoride, barium, sulfate, and silica. These constituents showed relatively large (greater than 50 percent) differences in concentrations between the source water and the ambient groundwater.

- Redox potential is a field parameter that is relatively inexpensive to measure and therefore can be frequently monitored during a pilot test. However, oxidation-reduction reactions between the source water and ambient groundwater would likely change the overall redox potential of both the source water and ambient groundwater, thus limiting its usefulness as a groundwater tracer.

- Fluoride and barium are constituents which are likely to behave more conservatively (less reaction) than some of the other recommended tracers, thus making them potentially reliable tracers for use during the pilot test. Fluoride was considered as a possible tracer in the ASR feasibility assessment for Richland’s Willowbrook Well; however, differences in fluoride concentrations between the source water and groundwater were not consistently large enough to make it a viable tracer (Golder Associates 2001a).

- The April 2005 data indicate large differences in sulfate concentrations between the source water and ambient groundwater; however, sulfate can be reduced readily to sulfide in reducing redox conditions, indicating limited utility as a tracer other than for qualitative purposes.

- The ambient groundwater had a substantially higher concentration of silica than the source water did, based on the April 2005 data, suggesting elevated silica measured in the recovered water could be indicative of recovering ambient groundwater. However, silica might readily form silicate minerals with other elements, depending on geochemical changes occurring with recharge and storage. Precipitation of silicates in amorphous or mineral form could limit its usefulness as a tracer.
- There were also large differences in gross alpha and beta concentrations, but these analyses are expensive and should be avoided if other viable options are available.

As discussed in Section 3, well 8N/29E-17E01 is completed within both the Saddle Mountains and Wanapum Basalt Aquifers and thus the water quality sample could represent a mixture of ambient groundwater from both aquifers. Therefore, other constituents or field parameters may also be viable tracers depending on ambient groundwater quality measured in the ASR well used for pilot testing. This could be better assessed based on sampling results from the baseline testing of the ASR well.

For example, dissolved oxygen (DO) is a field parameter that has potential to be used as an easily measured tracer during an ASR pilot test. Although DO concentrations between the source water and ambient groundwater were relatively close within the target ASR location; several wells within the project area, including 9N/28E-36P01, have relatively low DO concentrations compared to the source water. Therefore, the higher DO in the aerobic source water would be consumed readily if introduced to an anoxic aquifer; therefore DO could be used only qualitatively to document mixing with anoxic ambient groundwater if that is documented in the ASR well.

Nitrate concentrations should also be considered as a possible groundwater tracer. Although comparison between the source water and ambient groundwater did not show large differences in nitrate concentrations, Steinkampf (1989) showed that nitrogen (nitrate-plus-nitrite, as nitrogen) concentrations for the Wanapum formation are relatively low (below 2.0 mg/L) for the project area, which is consistent with Wanapum water quality data elsewhere in WRIA 31 (Aspect Consulting 2005). In addition, well 8N/29E-17Q01, which is located within the target ASR area and is completed within the Roza member of the Wanapum Basalt, demonstrated relatively low nitrate concentrations (0.17 mg/l) when sampled in February 1988. It is therefore likely that groundwater from the Wanapum Basalt would have a lower nitrogen (nitrate/nitrite) concentration than the source water, thus making it a feasible tracer for the pilot ASR test. Nitrogen will change oxidation state depending on groundwater redox conditions (nitrate when oxidizing; nitrite when reducing), therefore, both nitrate and nitrite would need to be measured in the initial pilot test.

As discussed in previous sections, trihalomethanes (THMs) and haloacetic acids (HAAs) are byproducts of chlorine disinfection found within the source water but not within the ambient groundwater. Therefore, it would seem plausible that these constituents could be used as an artificial tracer for the recharged water. However, concentrations of THMs and HAAs have been found to decline relatively quickly when source water is stored within anoxic groundwater conditions due to biologic degradation (see Section 3.10.2). Because THMs are absent in the storage aquifer, THMs could be used to document presence of recharge water in the recovered water, but, because of their potential to degrade during storage, would not be used to quantitatively estimate mixing/recoverability.

Bromide and chloride are generally nonreactive constituents and are often used as tracers in groundwater investigations. Concentration differences on the order of 30 percent were detected for these constituents in the April 2005 source and groundwater samples. Concentrations of chloride and bromide should be confirmed in groundwater of the actual ASR well during baseline testing to determine whether these might be useful tracers for use during the pilot test.

While temperature of the groundwater and source water showed only a 9 percent difference in the April 2005 sampling (Table 5), regional information suggests the target aquifer (Priest Rapids member of Wanapum Basalt) may have higher water temperatures than indicated from that sample. As such, water temperature may also have promise, at least qualitatively, as an easily measured indicator of water mixing.

It is important to note that not all of the possible tracers discussed in the preceding paragraphs may behave conservatively when mixed with the ambient groundwater, meaning they could undergo chemical reactions which would change the relative concentrations of the constituents. Therefore, a decision on the best tracers would have to be made based on comprehensive water quality sampling during the initial ASR pilot test. Analytes for subsequent testing would then be refined to collect only those water quality data useful for documenting ASR performance.

### *5.7.2 Ambient Groundwater in Storage Aquifer*

Analyses of ambient groundwater quality in the storage aquifer will be performed during the baseline step recovery test. The baseline water quality analyses will document background groundwater conditions in the target aquifer preceeding the initial recharge cycle. During the baseline step recovery test, the field parameters temperature, pH, dissolved oxygen, redox potential, specific conductivity, turbidity, methane, and hydrogen sulfide will be monitored at approximately 15 minute intervals (expected pumping duration of up to 8 hours). In addition to the collection of field parameters, a one-time sampling event will be performed near the end of the baseline step test. This sample will be analyzed for a comprehensive suite of general chemistry constituents and disinfection byproducts (Table 8).

### *5.7.3 Recharge Source Water*

Water quality analyses of the recharge source water will be performed during the 21-day recharge cycle of the initial pilot test. Field parameters will be measured daily to evaluate general water quality changes in the source water over the recharge duration. Total suspended solids (TSS) will also be analyzed daily to closely track the mass of suspended solids entering the ASR well during recharge. The other constituents in the monitoring program will be analyzed both at the start of the recharge cycle and at an approximate 7-day interval thereafter during the recharge cycle (total of 4 sample events). Disinfection byproducts will be monitored to document the range of concentrations in the recharge water, and ensure compliance with drinking water standards and the antidegradation policy. Prospective tracers will be monitored during the recharge cycle in order to document their ranges of concentrations for comparison during the storage and recovery cycles. It is possible that, once the actual ASR well groundwater quality is known, constituents other than those identified above may prove to be better choices as a tracer from which to estimate water quality mixing. The comprehensive list of general water quality and drinking water parameters will document the range of concentrations in the source water and confirm that the source water meets drinking water standards.

### 5.7.4 Stored Water

Water quality monitoring of water stored in the aquifer will occur during the 42-day storage cycle of the pilot test. Field parameters, prospective tracers, and disinfection byproducts will be sampled at an approximately 7-day interval during the storage cycle (total of 7 sample events). Water quality analyses performed during the storage cycle of the pilot test are primarily meant to monitor changes in constituent concentrations due to physical mixing and/or chemical reactions between the source water and ambient groundwater. Disinfection byproducts are monitored to ensure they remain below drinking water standards, and to evaluate potential concentration changes caused by their creation (reaction of residual chlorine with natural organic matter) and/or degradation and dispersion in the storage aquifer. The full list of general water quality and drinking water parameters will analyzed at an approximately 14-day interval (4 samples total) to document potential concentration changes relative to the recharge water that may occur during storage (Table 8).

### 5.7.5 Recovered Water

Water quality monitoring of recovered water will occur during the 28-day recovery cycle of the initial pilot test. Field parameters will be measured daily throughout recovery to document general water quality changes. Disinfection byproducts will be sampled at an approximately 3-day interval during the recovery cycle (10 sample events) to document compliance with drinking water standards. Prospective tracer constituents will also be analyzed at an approximately 3-day interval, in order to estimate the proportion of recharge water and ambient groundwater being recovered over time. The full list of general water quality/drinking water parameters will be analyzed at an approximately 7-day interval (5 samples) to document water quality changes throughout recovery and in how potentially changing water quality compares with drinking water standards (Table 8).

### 5.7.6 Water Quality Monitoring Data Evaluation

Reported laboratory analytical results will be qualified by the laboratory to identify quality control (QC) concerns in accordance with the specifications of the analytical methods. An independent data quality review summary can also be completed. Data quality review will be performed in accordance with EPA National Functional Guidelines with regard to the following, as appropriate to the particular analysis and using laboratory QC criteria:

- Sample documentation/custody;
- Holding times;
- Method blanks (representativeness);

- Reporting limits;
- Laboratory and field duplicate RPDs (precision);
- Blank spike and matrix spike percent recoveries (accuracy);
- Comparability; and
- Completeness.

The water quality data will be evaluated to evaluate concentrations in the recharge, stored, and recovered waters relative to drinking water standards and the antidegradation policy. In addition, data from the complete program should be evaluated thoroughly to identify tracers that best document water quality mixing (e.g., tracer breakthrough curves) and thus help assess recoverability of the recharge water. The fate of disinfection byproducts in the aquifer can be illustrated by plotting concentrations with concentrations of residual chlorine over time throughout the full initial test program.

## 5.8 Threshold Values

Threshold values for operation of the initial ASR pilot test include:

- Recharge water will meet drinking water standards.
- Recharge rates will be maintained so as to not cause the water level within the ASR well casing to approach ground surface.
- Recovery pumping rates will be maintained so as to not dewater the pump in the ASR well.
- Recharge and recovery will be maintained so as to not impair use of neighboring wells completed in the target aquifer or the overlying Saddle Mountains Aquifer.
- Recovery water returned to the City’s water distribution system will meet state drinking water standards for Group A public water systems and other requirements that the City may have.

## 5.9 Reporting of Initial Pilot Test

Following completion of the initial pilot test outlined above, a report of test findings should be prepared for review and discussion prior to proceeding with subsequent testing cycles. The report would include the results and evaluation of the hydraulic and water quality monitoring from the initial test as outlined above. The report should make preliminary conclusions regarding feasible recharge and recovery rates for the ASR well, water quality relative to drinking water standards throughout the duration of the ASR cycle, recoverability of the water recharged, and available storage volume using this ASR well. If warranted based on water quality differences between source and aquifer ambient water qualities, geochemical modeling could also be conducted to evaluate geochemical reactions (e.g., mineral precipitation) that could reduce hydraulic performance of the ASR well. The report should also make recommendations for subsequent testing, including revisions to hydraulic and/or water quality monitoring so as to efficiently collect those data most useful for evaluating feasibility and practicality of pursuing ASR as a water supply alternative for City of Kennewick.

# 6 Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of WRIA 31 Planning Unit for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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## Table 1. Summary of Well Information for Project Area - Well Depths Greater than 500 feet

| Well Owner | TRS Identifier | State Plane Coordinates X | Y | Elevation (ft) | Coordinate Source | Coordinate Accuracy | Well Depth (ft) | Top of Open Area (ft) | Bottom of Open Area (ft) | Well Type | Well Diameter (in) | Completion Date | SWL (ft) | Well Yield (gpm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BADGER MT. IRRIGATION DISTRICT #2 | 8N/28E-3R01 | 2307239 | 319178 | 709 | ASPECT | GPS | 900 | N/A | N/A | W | 16 | 1/17/02 | 240.5 | 576 |
| JERRY D. SMITH | 8N/28E-3M01 | 2303193 | 320236 | 827 | ECOLOGY | QTR-QTR | 633 | 625 | 633 | W | 8 | 9/11/75 | 295 | N/A |
| BADGER MOUNTAIN IRRIGATION DIST #4 | 8N/28E-4Q01 | 2300545 | 319005 | 902 | ASPECT | GPS | 645 | 585 | 602 | W | 10 | 1/17/02 | 468 | 400 |
| CIRCLE M FARMS | 8N/28E-9N01 | 2297899 | 313682 | 1075 | USGS | GPS | 830 | 815 | 830 | W | 8 | 4/20/90 | N/A | N/A |
| JOHN B MICHEL | 8N/28E-9F01 | 2299679 | 316049 | 935 | USGS | GPS | 1262 | 920 | 1262 | W | 16 | 12/9/91 | 484 | N/A |
| JAMES HOLLAND | 8N/28E-12N01 | 2314382 | 313844 | 750 | USGS | GPS | 540 | 20 | 540 | W | 6 | 2/27/75 | N/A | 26 |
| BECKY HOWLAND | 8N/28E-13N01 | 2314100 | 309083 | 778 | ECOLOGY | QTR-QTR | 507 | 483 | 506 | W | 8 | 8/19/04 | 460 | 50 |
| BILL HANGARTNER | 8N/28E-13M01 | 2314069 | 310410 | 741 | ECOLOGY | QTR-QTR | 500 | 470 | 500 | W | 6 | 8/23/01 | N/A | 25 |
| GAYLAND BAKER | 8N/28E-13N02 | 2314100 | 309083 | 778 | ECOLOGY | QTR-QTR | 780 | 565 | 780 | W | 8 | 8/3/04 | 459 | 60 |
| LARRY HUTCHISON | 8N/28E-13R01 | 2318084 | 309086 | 928 | ECOLOGY | QTR-QTR | 766 | 544.5 | 768 | W | 8 | 7/29/99 | 485 | 40 |
| LARRY MCLANAHAN | 8N/28E-13C01 | 2315340 | 313065 | 666 | ECOLOGY | QTR-QTR | 575 | 536 | 575 | W | 8 | 5/2/91 | N/A | N/A |
| LEE BRANWOOD | 8N/28E-13N03 | 2314100 | 309083 | 778 | ECOLOGY | QTR-QTR | 520 | 500 | 520 | W | 8 | 1/9/04 | 420 | 40 |
| MIKE ORIVE | 8N/28E-13R02 | 2318084 | 309086 | 928 | ECOLOGY | QTR-QTR | 771 | 545 | 771 | W | 8 | 1/27/00 | 472 | 40 |
| PHILLIP HICKLE | 8N/28E-13N04 | 2314100 | 309083 | 778 | ECOLOGY | QTR-QTR | 504 | 484 | 504 | W | 8 | 4/10/04 | 462 | 50 |
| AARON RODRIGUEZ | 8N/28E-14SE2 | 2312082 | 309725 | 906 | ECOLOGY | QTR-QTR | 584 | 480 | 505 | W | 8 | 11/21/02 | 387 | 30 |
| JAMES PRUCHER | 8N/28E-14R01 | 2312764 | 309073 | 928 | ECOLOGY | QTR-QTR | 560 | 24 | 560 | W | 6 | 6/6/75 | 435 | 10 |
| JIM FAIRBANK | 8N/28E-14R02 | 2312764 | 309073 | 928 | ECOLOGY | QTR-QTR | 545 | 430 | 490 | W | 8 | 6/28/93 | 420 | 60 |
| JOHN GARRISON | 8N/28E-14R03 | 2312764 | 309073 | 928 | ECOLOGY | QTR-QTR | 522 | 493 | 550 | W | 8 | 4/24/03 | 425 | 20 |
| PAUL HAMSON | 8N/28E-14R04 | 2312764 | 309073 | 928 | ECOLOGY | QTR-QTR | 520 | 490 | 520 | W | 6 | 2/17/95 | 430 | 12 |
| RICK FESER | 8N/28E-14R05 | 2312764 | 309073 | 928 | ECOLOGY | QTR-QTR | 520 | 500 | 520 | W | 6 | 4/22/94 | 415 | 11 |
| STEVE BATES | 8N/28E-14SE1 | 2312082 | 309725 | 906 | ECOLOGY | QTR-QTR | 515 | 499 | 504 | W | 8 | 12/8/76 | N/A | 156 |
| TONY KOELLING | 8N/28E-14R06 | 2312764 | 309073 | 928 | ECOLOGY | QTR-QTR | 500 | 498 | 550 | W | 8 | 8/22/01 | 389 | 30 |
| AUDREY KOROTROV | 8N/28E-23A01 | 2312789 | 307752 | 971 | ECOLOGY | QTR-QTR | 783 | 580 | 783 | W | 8 | 10/15/03 | 484 | 75 |
| CHARLES MOARCOUX | 8N/28E-23NE | 2312127 | 307085 | 991 | ECOLOGY | QTR-QTR | 707 | 504 | 707 | W | 8 | 4/11/81 | 570 | 120 |
| DARREL DESMUT | 8N/28E-23C01 | 2310097 | 307718 | 965 | ECOLOGY | QTR-QTR | 723 | 605 | 723 | W | 8 | 5/12/94 | 470 | 75 |
| DENNIS SANDVIG | 8N/28E-23E01 | 2308776 | 306379 | 997 | ECOLOGY | QTR-QTR | 580 | 485 | 580 | W | 8 | 10/12/00 | 425 | 25 |
| ELNIE CHAPIN | 8N/28E-23C02 | 2310097 | 307718 | 965 | ECOLOGY | QTR-QTR | 825 | 30 | 825 | W | 8 | N/A | 550 | 100 |
| GREG AND SANDI TRUE | 8N/28E-23D01 | 2308751 | 307702 | 981 | ASPECT | GPS | 680 | 580 | 660 | W | 6 | 4/7/03 | 480 | 50 |
| GREG TRUE | 8N/28E-23NW | N/A | N/A | N/A | ECOLOGY | QTR-QTR | 800 | 537 | 800 | W | 6 | 7/26/86 | 520 | 60 |
| HENDERSON | 8N/28E-23N01 | 2308826 | 303731 | 1171 | ECOLOGY | QTR-QTR | 765 | 710 | 750 | W | 8 | 5/31/04 | 495 | 40 |
| HOWARD BRAGER | 8N/28E-23A02 | 2312789 | 307752 | 971 | ECOLOGY | QTR-QTR | 754 | 587 | 754 | W | 10 | 8/7/79 | N/A | N/A |
| JUAN MEZA | 8N/28E-23H01 | 2312811 | 306435 | 1014 | ECOLOGY | QTR-QTR | 725 | N/A | N/A | W | 8 | 5/20/01 | 585 | 25 |
| MICHAEL CUMMINGS | 8N/28E-23D02 | 2309524 | 307699 | 960 | USGS | GPS | 600 | 557 | 600 | W | 8 | 8/9/83 | 450 | 200 |
| MONTE BRADY | 8N/28E-23H02 | 2312811 | 306435 | 1014 | ECOLOGY | QTR-QTR | 710 | 45 | 710 | W | 8 | 6/3/94 | 600 | 30 |
| MONTE BRADY | 8N/28E-23H03 | 2312811 | 306435 | 1014 | ECOLOGY | QTR-QTR | 620 | 580 | 620 | W | 8 | 5/22/95 | 520 | 17 |
| SCOTT MUSSER | 8N/28E-23 | 2310802 | 305747 | 1106 | ECOLOGY | QTR-QTR | 725 | 590 | 725 | W | 8 | 2/5/92 | N/A | N/A |
| SOUTH GATE WATER CO | 8N/28E-23F01 | 2310046 | 306715 | 1010 | USGS | GPS | 1342 | 553 | 1342 | W | N/A | 7/17/99 | 569 | 1000 |
| SOUTHGATE WATER CO | 8N/28E-23F02 | 2310121 | 306397 | 1030 | ECOLOGY | QTR-QTR | 740 | 553 | 740 | W | 10 | 6/22/92 | 497 | 50 |
| TRISH MAHAFFEY | 8N/28E-23R01 | 2312857 | 303801 | 1050 | ECOLOGY | QTR-QTR | 815 | 640 | 815 | W | 6 | 8/17/02 | 500 | 45 |
| GLENN MILLER RANCH | 8N/28E-28C01 | 2299493 | 302324 | 1286 | ECOLOGY | QTR-QTR | 1083 | 330 | 1083 | W | 8 | 3/24/01 | 730 | 75 |
| BRIAN KRUMLAND | 8N/28E-34R01 | 2307634 | 293160 | 1555 | ECOLOGY | QTR-QTR | 750 | 290 | 750 | W | 8 | 3/7/01 | 536 | 8 |
| JAMES AND DONA FULLER | 8N/28E-34R02 | 2307634 | 293160 | 1555 | ECOLOGY | QTR-QTR | 1360 | 860 | 1360 | W | 8 | 8/7/02 | 1212 | 60 |
| PETE SHARP / EUGENE EWING | 8N/28E-34K01 | 2306271 | 294454 | 1624 | ECOLOGY | QTR-QTR | 1217 | 53 | 1217 | W | 8 | 8/1/78 | 947 | 80 |
| HAROLD THOMPSON 1 | 8N/29E-15G01 | 2337957 | 311250 | 591 | ASPECT | GPS | 762 | 97 | 762 | W | 12 | 10/17/79 | 74 | N/A |
| HAROLD THOMPSON 2 | 8N/29E-15P01 | 2336665 | 308666 | 755 | ECOLOGY | QTR-QTR | 760 | 90 | 760 | W | 8 | 11/10/77 | N/A | 100 |
| DAVE CRISSWELL | 8N/29E-16 | 2331892 | 310646 | 735 | ECOLOGY | QTR-QTR | 388 | N/A | N/A | W | 6 | 2/28/78 | 180 | 25 |
| EARL GILLIAM | 8N/29E-17H01 | 2328562 | 311261 | 751 | ASPECT | GPS | 460 | N/A | N/A | W | 6 | 5/17/84 | 280 | 40 |
| AIREFCO | 8N/29E-17R01 | 2328591 | 308549 | 873 | ECOLOGY | QTR-QTR | 710 | 40 | 710 | W | 8 | 6/12/86 | 449 | 30 |
| FRANK RAINE | 8N/29E-17R02 | 2328591 | 308549 | 876 | ASPECT | GPS | 715 | 695 | 715 | W | 6 | 7/22/99 | 439 | 35 |
| HAROLD BRINKLEY | 8N/29E-17Q01 | 2327261 | 308533 | 853 | ASPECT | GPS | 1000 | 730 | 810 | W | 10 | 12/17/82 | 200 | 200 |
| HAROLD BRINKLEY | 8N/29E-17E01 | 2324582 | 311150 | 840 | ASPECT | GPS | 625 | 350 | 625 | W | 6 | 9/12/01 | 250 | 30 |
| TRI CITY VIEW ORCHARD INC. 1 | 8N/29E-17Q02 | 2327261 | 308533 | 879 | ECOLOGY | QTR-QTR | 800 | 20 | 800 | W | 10 | 5/25/77 | 300 | 500 |
| TRI CITY VIEW ORCHARD INC. 2 | 8N/29E-18J01 | 2323269 | 309887 | 863 | ECOLOGY | QTR-QTR | 665 | 60 | 665 | W | 6 | 5/16/77 | N/A | N/A |
| J. P. & NICOLE LALIBERTE | 8N/29E-20NE | 2327943 | 306537 | 935 | ECOLOGY | QTR-QTR | 654 | 188 | 654 | W | 8 | 12/13/94 | 465 | 30 |
| BERT BENTON | 8N/29E-22D01 | 2335330 | 307350 | 869 | ECOLOGY | QTR-QTR | 800 | N/A | N/A | W | 8 | 7/6/95 | N/A | N/A |

## Table 1. Summary of Well Information for Project Area - Well Depths Greater than 500 feet

| Well Owner | TRS Identifier | State Plane Coordinates | | | Coordinate Source | Coordinate Accuracy | Well Depth (ft) | Top of Open Area (ft) | Bottom of Open Area (ft) | Well Type | Well Diameter (in) | Completion Date | SWL (ft) | Well Yield (gpm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | X | Y | Elevation (ft) | | | | | | | | | | |
| STAN MCDONALD | 8N/29E-22A01 | 2339432 | 307257 | 801 | ECOLOGY | QTR-QTR | 505 | 94 | 505 | W | 8 | 6/25/76 | 170 | N/A |
| WILLIARD CAMPBELL | 8N/29E-22A02 | 2339432 | 307257 | 801 | ECOLOGY | QTR-QTR | 802 | 522<br>722 | 542<br>765 | W | 8 | 4/6/53 | 435 | 17.5 |
| WILLIARD CAMPBELL | 8N/29E-22A03 | 2339432 | 307257 | 801 | ECOLOGY | QTR-QTR | 535 | 295 | 535.5 | W | 8 | 11/29/53 | 420 | 17 |
| FLEDERICK A. SCHMORDE | 8N/29E-24H01 | 2349966 | 305843 | 528 | ECOLOGY | QTR-QTR | 565 | 405 | 565 | W | 6 | 8/8/99 | 358 | 30 |
| TERRY MEIER | 9N/28E-26N01 | 2308219 | 329160 | 561 | ECOLOGY | QTR-QTR | 505 | 318<br>442 | 328<br>452 | W | 6 | 8/26/99 | 190 | 60 |
| FRANK STAPLES | 9N/28E-27J01 | 2306918 | 330499 | 545 | ECOLOGY | QTR-QTR | 525 | 168 | 525 | W | 12 | 4/8/77 | 193 | 800 |
| DENNIS DAVIN | 9N/28E-28C01 | 2299072 | 333153 | 915 | ECOLOGY | QTR-QTR | 555 | 310<br>425<br>508 | 315<br>440<br>538 | W | 10 | 8/23/84 | 317 | 100 |
| KENNEWICK IRRIGATION | 9N/28E-28B01 | 2300379 | 333137 | 725 | ECOLOGY | QTR-QTR | 600 | 530.5 | 600 | W | 10 | 4/17/96 | 117 | N/A |
| YAKIMA SHEEP CO. | 9N/28E-33M01 | 2297646 | 325187 | 840 | ECOLOGY | QTR-QTR | 535 | 68 | 535 | W | 8 | 10/23/54 | 410 | 8 |
| MILO BAUDER | 9N/28E-34H01 | 2306892 | 326528 | 699 | ECOLOGY | QTR-QTR | 905 | 370 | 905 | W | 16 | 12/24/77 | 266 | N/A |
| WILSUN | 9N/28E-34M01 | 2302921 | 325200 | 853 | ECOLOGY | QTR-QTR | 950 | 703 | 950 | W | 6 | 8/23/94 | 502 | 70 |
| QUADRANT CORPORATION (WILLOWBROOK) | 9N/28E-36P01 | 2315371 | 324334 | 480 | USGS | GPS | 1208 | 940 | 1208 | W | N/A | 1/18/79 | 88 | 1200 |

Notes:
N/A = No Information Available
W = Water
A = Abandoned

## Table 2. Hydraulic Parameters for the Saddle Mountains and Wanapum Basalt Aquifers

**Saddle Mountains**

| Hydraulic Conductivity (ft/day) | | | Transmissivity (ft$^2$/day) | | | Storativity (Dimensionless) | | | Location | Model/Aquifer Test | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | Maximum | Mean | Minimum | Maximum | Mean | Minimum | Maximum | Mean | | | |
| 0.17 | 3 | 1 | 2 | 1979 | 457 | 3.7E-06 | 1.1E-04 | | Columbia Plateau Aquifer System | Model | Hansen, Vacarro and Bauer, 1994 |
| 0.43 | 2 | | | | | | | | Kennewick ASR Project Area | Model | Hansen, Vacarro and Bauer, 1994 |
| 0.01 | 1892 | 56 | | | | | | | Columbia Plateau Aquifer System | Specific Capacity | Hansen, Vacarro and Bauer, 1994 |
| | | | 240 | 7400 | 2600 | | | 2.5E-03 | Columbia Basin Irrigation Project | Specific Capacity | Tanaka et al, 1974 |
| | | | 59 | 1970 | 471 | | | | Benton City - Numerous Wells | Specific Capacity | WDOE Well Log Database |
| | | | | | | | | 3.2E-02 | - | Model | A. Smith; USGS - Written Communication |
| | | | | | | | | 1.0E-02 | - | Model | F. A. Packard |
| 0.1 | 20 | 8 | 33 | 3067 | 824 | 3.7E-06 | 1.1E-04 | 9.3E-03 | | | Geometric Mean of Values |

**Wanapum**

| Hydraulic Conductivity (ft/day) | | | Transmissivity (ft$^2$/day) | | | Storativity (Dimensionless) | | | | | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | Maximum | Mean | Minimum | Maximum | Mean | Minimum | Maximum | Mean | | | |
| 0.09 | 8 | 3 | 4 | 9331 | 1339 | 3.0E-06 | 2.3E-04 | | Columbia Plateau Aquifer System | Model | Hansen, Vacarro and Bauer, 1994 |
| 0.43 | 7 | | | | | | | | Kennewick ASR Project Area | Model | Hansen, Vacarro and Bauer, 1994 |
| 0.01 | 5244 | 66 | | | | | | | Columbia Plateau Aquifer System | Specific Capacity | Hansen, Vacarro and Bauer, 1994 |
| | | 34 | | | 9000 | | | | Kennewick - Willowbrook Well | Pump Test | Golder Associates, 2001 |
| | | | | | 26000 | | | | Kennewick - BMID #4 Well | Pump Test | Golder Associates, 2003 |
| | | | | | | 1.2E-05 | 2.2E-05 | | - | Aquifer Test | Eddy, 1976 |
| | | | | | | 9.0E-05 | 4.8E-03 | | Walla Walla River Basin | Specific Capacity | MacNish and Barker, 1976 |
| | | | | | 51475 | | | 2.0E-04 | City of Walla Walla | Pump Test | Price, 1960 |
| | | | 270 | 40000 | | 1.5E-03 | 6.0E-03 | | Odessa-Lind Area | Model | Luzier and Skrivan, 1975 |
| | | | | | | 7.6E-04 | | | - | Aquifer Test | Tanaka et al, 1979 |
| | | | | | | | | 1.0E-03 | - | Model | F. A. Packard; USGS - Written Communication |
| 0.1 | 66 | 19 | 34 | 19320 | 11270 | 8.2E-05 | 6.2E-04 | 4.5E-04 | | | Geometric Mean of Values |

## Table 3. 2004 Actual and 2024 Projected Water Projection

| Month | 2004 actual production (MGD) | | 2024 projected production (MGD)* | | Current production capacity (MGD) | Near-future production capacity (MGD) |
|---|---|---|---|---|---|---|
| | Avg. Daily Demand | Peak Daily Demand | Avg. Daily Demand | Peak Daily Demand | | |
| Jan | 6.8 | 10.7 | 8.9 | 20.7 | 21.5 | 29 |
| Feb | 6.5 | 9.2 | 8.5 | 17.8 | 21.5 | 29 |
| Mar | 7.8 | 11.0 | 10.2 | 21.2 | 21.5 | 29 |
| Apr | 10.8 | 13.9 | 14.2 | 26.9 | 21.5 | 29 |
| May | 11.6 | 15.1 | 15.2 | 29.3 | 21.5 | 29 |
| Jun | 13.5 | 16.0 | 17.8 | 31.1 | 21.5 | 29 |
| Jul | 15.8 | 16.9 | 20.8 | 32.8 | 21.5 | 29 |
| Aug | 14.6 | 16.8 | 19.3 | 32.5 | 21.5 | 29 |
| Sep | 12.7 | 16.8 | 16.7 | 32.5 | 21.5 | 29 |
| Oct | 9.8 | 12.4 | 12.9 | 24.1 | 21.5 | 29 |
| Nov | 6.3 | 8.9 | 8.4 | 17.2 | 21.5 | 29 |
| Dec | 6.6 | 10.7 | 8.7 | 20.7 | 21.5 | 29 |
| **Average:** | **10.2** | **13.2** | **13.5** | **25.6** | | |

## Table 4. Acre-Feet of Water Stored under Variable Flow (MGD) and Timing (Month) Scenarios

| | | Months of Water Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | | |
| **Average MGD Stored** | **0.5** | 47 | 94 | 141 | 188 | 235 | 282 | **350** | **Average gpm Stored** |
| | **1.0** | 93 | 186 | 278 | 371 | 464 | 557 | **690** | |
| | **1.5** | 140 | 280 | 419 | 559 | 699 | 839 | **1,040** | |
| | **2.0** | 187 | 374 | 561 | 747 | 934 | 1,121 | **1,390** | |
| | **2.5** | 234 | 468 | 702 | 936 | 1,170 | 1,403 | **1,740** | |
| | **3.0** | 280 | 559 | 839 | 1,118 | 1,398 | 1,678 | **2,080** | |
| | **3.5** | 327 | 653 | 980 | 1,307 | 1,633 | 1,960 | **2,430** | |
| | **4.0** | 374 | 747 | 1,121 | 1,495 | 1,869 | 2,242 | **2,780** | |

# Table 5. Groundwater and Source Water Quality Data for Project Area

| Well Information | | | | | | | | Field Parameters | | | | | | | | General Chemistry | | | | | | | Common Cations (mg/L) | | | | Common Anions (mg/L) | | | Additional Anions (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well ID | TRS Identifier | Well Depth (ft) | Top of Screen | Bottom of Screen | Unit of Completion | Source | Sample Date | Temp (F) | pH | DO (mg/L) | EH (mv) | EC (uS/cm) | Turbidity (NTU) | CH4 (%) | H2S (ppm) | Alkalinity (mg/L) | Color (color units) | TDS (mg/L) | TSS (mg/L) | Ammonia (mg/L) | Cyanide (mg/L) | Organic Carbon | Calcium | Magnesium | Potassium | Sodium | Bicarbonate (mg/L) | Chloride | Sulfate | Bromide | Fluoride | Nitrate-N | Nitrite-N |
| BADGER MT. IRRIGATION DISTRICT #2 | 8N/28E-3R01 | 900 | N/A | N/A | Priest Rapids | BM Memo | | | | | | 471 | 0.1 | | | 109 | ND | | | | | | 30.3 | 8.2 | | 63.8 | | 8.7 | 75.3 | | 0.7 | < 0.2 | < 0.2 |
| JERRY D. SMITH | 8N/28E-3M01 | 633 | 625 | 633 | | USGS | 9/5/86 | | | | | 460 | | | | | | | | | | | | | | | | | | | | | |
| BADGER MOUNTAIN IRRIGATION DIST #4 | 8N/28E-4Q01 | 645 | 585 | 602 | Priest Rapids | BM Memo | 2/4/02 | 60 | N/A | N/A | | 360 | 0.9 | | | 114 | < 5 | | | | | | N/A | N/A | | 52 | | 5.39 | 51.5 | | 0.568 | < 0.05 | < 0.5 |
| JOHN B MICHEL | 8N/28E-9F01 | 1262 | 920 | 1262 | Roza | USGS | 9/5/01 | 78 | 8.1 | | | 438 | | | | | | | | 0.02 | | 1 | 15.9 | 6.92 | 13.5 | 62.3 | 220 | 9.48 | 30.1 | | 0.9 | | < 0.006 |
| JIM FAIRBANK | 8N/28E-14R02 | 545 | 430 | 490 | | Well Log | | 57 | | | | | | | | | | | | | | | | | | | | | | | | | |
| AUDREY KOROTROV | 8N/28E-23A01 | 783 | 580 | 783 | Priest Rapids | Well Log | | 58 | | | | | | | | | | | | | | | | | | | | | | | | | |
| DARREL DESMUT | 8N/28E-23C01 | 723 | 605 | 723 | Priest Rapids | Well Log | | 62 | | | | | | | | | | | | | | | | | | | | | | | | | |
| ELNIE CHAPIN | 8N/28E-23C02 | 825 | 30 | 825 | | USGS | | | | | | 482 | | | | | | | | | | | | | | | | | | | | | |
| GREG AND SANDI TRUE | 8N/28E-23D01 | 680 | 580 | 660 | Priest Rapids | Aspect | 4/27/05 | 62 | 7.93 | 6.72 | 147 | 399 | 3.03 | 0 | 0 | 156 | | 330 | | | | | 19.8 | 10.2 | 15.7 | 54.4 | 156 | 10.7 | 44.6 | | | | |
| SOUTH GATE WATER CO | 8N/28E-23F01 | 1342 | 553 | 1342 | Priest Rapids/Roza | Well Log | | 62 | | | | | | | | | | | | | | | | | | | | | | | | | |
| TRISH MAHAFFEY | 8N/28E-23R01 | 815 | 640 | 815 | Roza | Well Log | | 70 | | | | | | | | | | | | | | | | | | | | | | | | | |
| HAROLD THOMPSON | 8N/29E-15G01 | 762 | 97 | 762 | Saddle Mountains/Wanapum | Aspect | 4/26/05 | 64 | 7.45 | NA | 225 | 586 | 0.49 | 0 | 0 | 174 | | 414 | | | | | 60.2 | 25.9 | 7.36 | 27.2 | 174 | 26 | 82.2 | | | | |
| EARL GILLIAM | 8N/29E-17H01 | 460 | N/A | N/A | Umatilla/Priest Rapids | Aspect | 4/27/05 | 57 | 7.72 | 4 | 179 | 374 | 3.25 | 0 | 0 | 168 | | 310 | | | | | 11.7 | 6.21 | 10.6 | 71.2 | 168 | 8.54 | 27.4 | | | | |
| FRANK RAINE | 8N/29E-17R02 | 715 | 695 | 715 | Priest Rapids | DOH | | | | | | 600 | 3.6 | | | 130 | 5 | | | | | | 29 | 14 | | 66 | | 26 | 75 | | 1.1 | 2.2 | < 0.5 |
| HAROLD BRINKLEY | 8N/29E-17Q01 | 1000 | 730 | 810 | Roza | USGS | 2/18/88 | 46 | 8.3 | 0.7 | | 471 | | | | | | | | < 0.01 | | | 18 | 9 | 3.9 | 64 | 215 | 11 | 48 | | 0.9 | 0.17 | |
| HAROLD BRINKLEY | 8N/29E-17E01 | 625 | 350 | 625 | Umatilla/Priest Rapids | Aspect | 4/26/05 | 63 | 7.67 | 6.51 | 185 | 454 | 0.95 | 0.1 | 0 | 148 | 10 | 341 | < 4 | < 0.04 | < 0.05 | 2.54 | 43.3 | 21.1 | < 3 | 27.2 | 148 | 21.1 | 51.4 | 0.117 | 0.415 | 2.64 | < 0.015 |
| J. P. & NICOLE LALIBERTE | 8N/29E-20NE | 654 | 188 | 654 | Saddle Mountains | DOH | | 59 | | | | 567 | 8.77 | | | 83 | 5 | | | | | | | | | 87.3 | | 20 | | | 0.59 | 0.35 | 0.5 |
| WILLIARD CAMPBELL | 8N/29E-22A02 | 802 | 522<br>722 | 542<br>765 | Roza | USGS | 11/17/70 | 73 | 7.3 | 0.1 | | 1240 | | | | 550 | | | | | | | 103 | 72 | 17 | 58 | 184 | 16 | 512 | | 0.4 | < 0.1 | |
| FRANK STAPLES | 9N/28E-27J01 | 525 | 168 | 525 | | USGS | 6/24/82 | 66 | 7.3 | | | 1010 | | | | 410 | | | | | | | 86 | 47 | 13 | 57 | 354 | 47 | 180 | | 0.3 | 8.2 | |
| THE QUADRANT CORPORATION (WILLOWBROOK) | 9N/28E-36P01 | 1208 | 940 | 1208 | Priest Rapids | BM Memo | 9/25/00 | 70 | 7.65 | 0.36 | 355 | 167 | N/A | | | 72 | N/A | 130 | < 2 | < 0.04 | N/A | 1.7 | 15 | 3.7 | < 5 | 22 | | 6 | 19 | < 0.03 | 0.3 | 0.031 | < 0.03 |
| Ranney Collector #4 | | | | | N/A | ASR Willowbrook | 1996-2000 | | 7.0 - 7.6 | | | 290 - 601 | 0.23 - 0.35 | | | 165 - 214 | < 5 | 365 | | | < 0.005 | < 1.0 - 4.0 | | | | 14.6 - 28.1 | | 7.36 - 17 | 19.1 - 37.2 | | 0.16 - 0.247 | 0.82 - 3.9 | < 0.5 |
| Ranney Collector #5 | | | | | N/A | ASR Willowbrook | 1996-2000 | | 7.0 - 7.8 | | | 285 - 696 | 0.177 - 0.23 | | | 117 - 182 | < 5 | 187 - 224 | | | < 0.005 | < 1.0 - 16 | | | | 15.8 | | 8.99 - 9.04 | 20.5 - 29.6 | | 0.15 - 0.2 | 1.64 - 3.27 | < 0.5 |
| Water Treatment Plant | | | | | N/A | ASR Willowbrook | 1996-2000 | | 7.6 - 8.2 | | | 121 - 129 | < 0.05 - 0.197 | | | 53 - 62 | < 5 | 74 - 102 | | | < 0.005 | < 1.0 - 4.0 | | | | 3.18 - 4.23 | | 4.43 - 6.3 | 6.19 - 8.7 | | 0.057 - 0.20 | 0.16 - 0.27 | < 0.5 |
| Kennewick Water Distribution System | | | | | N/A | ASR Willowbrook | 10/2/00 | 74 | 7.23 | 7.45 | 853 | 167 | 0.17 | | | 87 | | 160 | < 2 | < 0.04 | < 0.05 | 1.3 | 26 | 8.7 | < 5 | 9.9 | | 7.5 | 16 | < 0.03 | 0.11 | 0.92 | < 0.03 |
| Water Distribution System (Reservoir 4) | | | | | N/A | Aspect | 4/26/05 | 58 | 7.26 | 6.78 | 740 | 428 | 0.87 | 0 | 0 | 165 | 10 | 291 | < 4 | < 0.04 | < 0.05 | 2.42 | 47.3 | 16.6 | 3.83 | 24 | 165 | 16.6 | 31.8 | < 0.05 | 0.176 | 2.93 | < 0.015 |
| *Percent Difference in Constituent Concs (Brinkley 17E01 - Reservoir 4)* | | | | | | . | | *9%* | *6%* | *-4%* | *-75%* | *6%* | *9%* | *NC* | *NC* | *-10%* | *NC* | *17%* | *NC* | *NC* | *NC* | *5%* | *-8%* | *27%* | | *13%* | *-10%* | *27%* | *62%* | | *136%* | *-10%* | |
| Regional average for Saddle Mountains (1) | | | | | N/A | Whiteman | | 65 | 7.7 | 4.5 | | 498 | | | | | | 340.2 | | | | | 38.3 | 19.4 | 6.9 | 34.5 | 195.4 | 24.3 | 53 | | 0.58 | | |
| Regional average for Wanapum (2) | | | | | N/A | Whiteman | | 60 | 7.4 | 5.2 | | 403 | | | | | | 269.5 | | | | | 32.8 | 14.8 | 4.9 | 28 | 178.1 | 17.2 | 29.3 | | 0.5 | | |
| Federal MCL(3) | | | | | N/A | USEPA | | | | | | | 5 | | | | | | | | | | | | | | | | | | 4 | 10 | |
| Federal SMCL (3) | | | | | N/A | USEPA | | | 6.5 - 8.5 | | | | | | | | 15 | | | | | | | | | | | 250 | 250 | | 2 | | |
| State MCL (4) | | | | | N/A | WAC | | | | | | 700 | | | | | 15 | | | | | | | | | 20 | | 250 | 250 | | 4 | 10 | 1 |

[1] Mean value based on 131 water analyses (Steinkampf 1989)

[2] Mean value based on 410 water analyses (Steinkampf 1989)

[3] From USEPA 2004 Edition of the Drinking Water Standards and Health Advisories

[4] From WAC 246-290-310

Notes:
Well ID is from the well log or other source, and may not represent current well ownership.
NA: Unreliable reading.  NC: Not calculated; at least one value is below detection limit.
Shaded values are above respective MCL concentrations.
U indicates the result is less than the reported detection limit.
J indicates estimated concentration below laboratory detection limit.

## Table 5. Groundwater and Source Water Quality Data for Project Area

| Well Information | | | | | | | | Metals (mg/L) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well ID | TRS Identifier | Well Depth (ft) | Top of Screen | Bottom of Screen | Unit of Completion | Source | Sample Date | Arsenic | Antimony | Aluminum | Barium | Beryllium | Boron | Cadmium | Chromium | Copper | Iron | Lead | Lithium | Manganese | Mercury | Methane | Nickel | Phosphorus | Selenium | Silica | Silver | Thallium | Strontium | Zinc |
| BADGER MT. IRRIGATION DISTRICT #2 | 8N/28E-3R01 | 900 | N/A | N/A | Priest Rapids | BM Memo | | < 0.001 | | | 0.075 | < 0.001 | | < 0.001 | < 0.005 | < 0.01 | 0.06 | < 0.001 | | 0.021 | < 0.0005 | N/A | < 0.02 | | < 0.001 | | < 0.005 | | | < 0.01 |
| JERRY D. SMITH | 8N/28E-3M01 | 633 | 625 | 633 | | USGS | 9/5/86 | | | | | | | | | | | | | | | | | | | | | | | |
| BADGER MOUNTAIN IRRIGATION DIST #4 | 8N/28E-4Q01 | 645 | 585 | 602 | Priest Rapids | BM Memo | 2/4/02 | < 0.005 | | | 0.066 | < 0.003 | | < 0.002 | < 0.01 | 0.199 | 0.472 | < 0.002 | | 0.065 | < 0.0005 | N/A | < 0.03 | | < 0.005 | | < 0.01 | | | 0.057 |
| JOHN B MICHEL | 8N/28E-9F01 | 1262 | 920 | 1262 | Roza | USGS | 9/5/01 | | | | | | | | | | 0.012 | | | 0.023 | | | | 0.01 | | 68 | | | | |
| JIM FAIRBANK | 8N/28E-14R02 | 545 | 430 | 490 | | Well Log | | | | | | | | | | | | | | | | | | | | | | | | |
| AUDREY KOROTROV | 8N/28E-23A01 | 783 | 580 | 783 | Priest Rapids | Well Log | | | | | | | | | | | | | | | | | | | | | | | | |
| DARREL DESMUT | 8N/28E-23C01 | 723 | 605 | 723 | Priest Rapids | Well Log | | | | | | | | | | | | | | | | | | | | | | | | |
| ELNIE CHAPIN | 8N/28E-23C02 | 825 | 30 | 825 | | USGS | | | | | | | | | | | | | | | | | | | | | | | | |
| GREG AND SANDI TRUE | 8N/28E-23D01 | 680 | 580 | 660 | Priest Rapids | Aspect | 4/27/05 | | | | | | | | | | 0.25 | | | 0.0461 | | | | | | | | | | |
| SOUTH GATE WATER CO | 8N/28E-23F01 | 1342 | 553 | 1342 | Priest Rapids/Roza | Well Log | | | | | | | | | | | | | | | | | | | | | | | | |
| TRISH MAHAFFEY | 8N/28E-23R01 | 815 | 640 | 815 | Roza | Well Log | | | | | | | | | | | | | | | | | | | | | | | | |
| HAROLD THOMPSON | 8N/29E-15G01 | 762 | 97 | 762 | Saddle Mountains/Wanapum | Aspect | 4/26/05 | | | | | | | | | | < 0.1 | | | < 0.02 | | | | | | | | | | |
| EARL GILLIAM | 8N/29E-17H01 | 460 | N/A | N/A | Umatilla/Priest Rapids | Aspect | 4/27/05 | | | | | | | | | | 0.605 | | | < 0.02 | | | | | | | | | | |
| FRANK RAINE | 8N/29E-17R02 | 715 | 695 | 715 | Priest Rapids | DOH | | 0.01 | | | 0.1 | 0.003 | | 0.002 | 0.01 | 0.2 | 0.59 | 0.002 | | 0.029 | 0.0005 | | 0.04 | | 0.005 | | 0.01 | | | 0.2 |
| HAROLD BRINKLEY | 8N/29E-17Q01 | 1000 | 730 | 810 | Roza | USGS | 2/18/88 | | | | | | | | | | | | | | | | | | | 55 | | | | |
| HAROLD BRINKLEY | 8N/29E-17E01 | 625 | 350 | 625 | Umatilla/Priest Rapids | Aspect | 4/26/05 | 0.00259 | 0.00118 | < 0.1 | 0.023 | < 0.005 | | < 0.005 | < 0.02 | 0.0529 | < 0.1 | 0.00178 | | < 0.02 | < 0.0002 | | < 0.02 | | 0.0015 | 103 | < 0.01 | < .001 | | 0.154 |
| J. P. & NICOLE LALIBERTE | 8N/29E-20NE | 654 | 188 | 654 | Saddle Mountains | DOH | | 0.01 | | | 0.1 | 0.003 | | 0.002 | 0.01 | 0.2 | 2.09 | 0.002 | | 0.08 | 0.0005 | | 0.04 | | 0.005 | | 0.01 | | | 0.207 |
| WILLIARD CAMPBELL | 8N/29E-22A02 | 802 | 522<br>722 | 542<br>765 | Roza | USGS | 11/17/70 | | | | | | 0.03 | | < 0.03 | < 0.05 | 0.03 | < 0.1 | 0.03 | 0.2 | | | | | | 53 | | | 0.55 | < 0.01 |
| FRANK STAPLES | 9N/28E-27J01 | 525 | 168 | 525 | | USGS | 6/24/82 | | | | | | | | | | 0.003 | | | | | | | | | 73 | | | | |
| THE QUADRANT CORPORATION (WILLOWBROOK) | 9N/28E-36P01 | 1208 | 940 | 1208 | Priest Rapids | BM Memo | 9/25/00 | < 0.006 | < 0.003 | < 0.2 | 0.037 | < 0.002 | < 0.5 | < 0.0005 | < 0.01 | < 0.01 | < 0.1 | < 0.0005 | | 0.014 | N/A | 2 | < 0.04 | | < 0.003 | | < 0.1 | < 0.0005 | | < 0.01 |
| Ranney Collector #4 | | | | | N/A | ASR Willowbrook | 1996-2000 | < 0.005 | < 0.003 | | 0.057 - 0.063 | < 0.004 | | < 0.004 | < 0.010 | < 0.010 | 0.035 - 0.24 | < 0.002 | | < 0.01 - 0.028 | < 0.0002 | | < 0.040 | | < 0.005 | | < 0.01 | < 0.002 | | < 0.02 |
| Ranney Collector #5 | | | | | N/A | ASR Willowbrook | 1996-2000 | < 0.005 | < 0.003 | | 0.031 - 0.039 | < 0.003 | | < 0.002 | < 0.010 | < 0.010 | 0.01 | < 0.002 | | < 0.01 - 0.01 | < 0.0002 | | < 0.040 | | < 0.005 | | < 0.01 | < 0.002 | | < 0.02 - 0.027 |
| Water Treatment Plant | | | | | N/A | ASR Willowbrook | 1996-2000 | < 0.005 | < 0.003 | | 0.02 - 0.031 | < 0.003 | | < 0.002 | < 0.010 | < 0.010 | < 0.01 - 0.2 | < 0.002 | | < 0.01 - 0.011 | < 0.0002 | | < 0.040 | | < 0.005 | | < 0.01 | < 0.002 | | < 0.02 |
| Kennewick Water Distribution System | | | | | N/A | ASR Willowbrook | 10/2/00 | < 0.003 | < 0.003 | < 0.2 | 0.032 | < 0.002 | < 0.5 | < 0.0005 | < 0.01 | < 0.01 | < 0.1 | 0.00081 | | < 0.005 | | | < 0.04 | | < 0.003 | | < 0.01 | < 0.0005 | | 0.069 |
| Water Distribution System (Reservoir 4) | | | | | N/A | Aspect | 4/26/05 | < 0.001 | < 0.001 | < 0.1 | 0.0581 | < 0.005 | | < 0.005 | < 0.02 | < 0.02 | < 0.1 | < 0.001 | | < 0.02 | < 0.0002 | | < 0.02 | | < 0.001 | 27.6 | < 0.01 | < 0.001 | | < 0.015 |
| *Percent Difference in Constituent Concs (Brinkley 17E01 - Reservoir 4)* | | | | | | . | | *NC* | *NC* | *NC* | *-60%* | *NC* | | *NC* | *NC* | *NC* | *NC* | *NC* | | *NC* | *NC* | | *NC* | | *NC* | *273%* | *NC* | *NC* | | *NC* |
| Regional average for Saddle Mountains (1) | | | | | N/A | Whiteman | | | | | | | | | | | 0.03 | | | | | | | | | 55.6 | | | | |
| Regional average for Wanapum (2) | | | | | N/A | Whiteman | | | | | | | | | | | 0.03 | | | | | | | | | 48.3 | | | | |
| Federal MCL(3) | | | | | N/A | USEPA | | 0.01 | | | 2 | | | 0.005 | 0.1 | 1.3 | | 0.015 | | | 0.002 | | | | 0.05 | | | | | |
| Federal SMCL (3) | | | | | N/A | USEPA | | | | | | | | | | 1 | 0.3 | | | 0.05 | | | | | | | 0.1 | | | 5 |
| State MCL (4) | | | | | N/A | WAC | | 0.05 | | | 2 | 0.004 | | 0.005 | 0.1 | 1.3 | 0.3 | 0.015 | | 0.05 | 0.002 | | 0.1 | | 0.05 | | 0.1 | | | 5 |

[1] Mean value based on 131 water analyses (Steinkampf 1989)
[2] Mean value based on 410 water analyses (Steinkampf 1989)
[3] From USEPA 2004 Edition of the Drinking Water Standards and Health Advisories
[4] From WAC 246-290-310

Notes:
Well ID is from the well log or other source, and may not represent current well ownership.
NA: Unreliable reading. NC: Not calculated; at least one value is below detection limit.
Shaded values are above respective MCL concentrations.
U indicates the result is less than the reported detection limit.
J indicates estimated concentration below laboratory detection limit.

## Table 5. Groundwater and Source Water Quality Data for Project Area

| Well Information | | | | | | | | Trihalomethanes (ug/L) | | | | | Halo-Acetic Acids (ug/L) | | | | | | | Radiochemistry (pCi/L) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well ID | TRS Identifier | Well Depth (ft) | Top of Screen | Bottom of Screen | Unit of Completion | Source | Sample Date | Chloroform | Bromo-dichloro-methane | Dibromo-chloro-methane | Bromoform | Calculated Total THM | Mono-chloro-acetic Acid | Di-chloro-acetic Acid | Tri-chloro-acetic Acid | Mono-bromo-acetic Acid | Dibromo-acetic Acid | Calculated Total HAA(5) | Bromo-chloro-acetic Acid | Gross Alpha | Gross Beta | Radium - 226 | Radium - 228 | Ra-226 + Ra-228 | Tritium | Strontium 90 |
| BADGER MT. IRRIGATION DISTRICT #2 | 8N/28E-3R01 | 900 | N/A | N/A | Priest Rapids | BM Memo | | | | | | | | | | | | | | | | | | | | |
| JERRY D. SMITH | 8N/28E-3M01 | 633 | 625 | 633 | | USGS | 9/5/86 | | | | | | | | | | | | | | | | | | | |
| BADGER MOUNTAIN IRRIGATION DIST #4 | 8N/28E-4Q01 | 645 | 585 | 602 | Priest Rapids | BM Memo | 2/4/02 | | | | | | | | | | | | | | | | | | | |
| JOHN B MICHEL | 8N/28E-9F01 | 1262 | 920 | 1262 | Roza | USGS | 9/5/01 | | | | | | | | | | | | | | | | | | | |
| JIM FAIRBANK | 8N/28E-14R02 | 545 | 430 | 490 | | Well Log | | | | | | | | | | | | | | | | | | | | |
| AUDREY KOROTROV | 8N/28E-23A01 | 783 | 580 | 783 | Priest Rapids | Well Log | | | | | | | | | | | | | | | | | | | | |
| DARREL DESMUT | 8N/28E-23C01 | 723 | 605 | 723 | Priest Rapids | Well Log | | | | | | | | | | | | | | | | | | | | |
| ELNIE CHAPIN | 8N/28E-23C02 | 825 | 30 | 825 | | USGS | | | | | | | | | | | | | | | | | | | | |
| GREG AND SANDI TRUE | 8N/28E-23D01 | 680 | 580 | 660 | Priest Rapids | Aspect | 4/27/05 | | | | | | | | | | | | | | | | | | | |
| SOUTH GATE WATER CO | 8N/28E-23F01 | 1342 | 553 | 1342 | Priest Rapids/Roza | Well Log | | | | | | | | | | | | | | | | | | | | |
| TRISH MAHAFFEY | 8N/28E-23R01 | 815 | 640 | 815 | Roza | Well Log | | | | | | | | | | | | | | | | | | | | |
| HAROLD THOMPSON | 8N/29E-15G01 | 762 | 97 | 762 | Saddle Mountains/Wanapum | Aspect | 4/26/05 | | | | | | | | | | | | | | | | | | | |
| EARL GILLIAM | 8N/29E-17H01 | 460 | N/A | N/A | Umatilla/Priest Rapids | Aspect | 4/27/05 | | | | | | | | | | | | | | | | | | | |
| FRANK RAINE | 8N/29E-17R02 | 715 | 695 | 715 | Priest Rapids | DOH | | | | | | | | | | | | | | | | | | | | |
| HAROLD BRINKLEY | 8N/29E-17Q01 | 1000 | 730 | 810 | Roza | USGS | 2/18/88 | | | | | | | | | | | | | | | | | | | |
| HAROLD BRINKLEY | 8N/29E-17E01 | 625 | 350 | 625 | Umatilla/Priest Rapids | Aspect | 4/26/05 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 2 | < 2 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | 2.66 J | 3.94 J | 0.13 U | | | 260 U | 2.32 U |
| J. P. & NICOLE LALIBERTE | 8N/29E-20NE | 654 | 188 | 654 | Saddle Mountains | DOH | | | | | | | | | | | | | | | | | | | | |
| WILLIARD CAMPBELL | 8N/29E-22A02 | 802 | 522<br>722 | 542<br>765 | Roza | USGS | 11/17/70 | | | | | | | | | | | | | | | | | | | |
| FRANK STAPLES | 9N/28E-27J01 | 525 | 168 | 525 | | USGS | 6/24/82 | | | | | | | | | | | | | | | | | | | |
| THE QUADRANT CORPORATION (WILLOWBROOK) | 9N/28E-36P01 | 1208 | 940 | 1208 | Priest Rapids | BM Memo | 9/25/00 | 5.1 | 0.59 | 0.22 | < 0.4 | 5.9 | | | | | | | | | | | | | | |
| Ranney Collector #4 | | | | | N/A | ASR Willowbrook | 1996-2000 | | | | | | | | | | | | | 1.12 - 9.70 | 2.84 - 7.90 | | | | 42.75 | 0.236 |
| Ranney Collector #5 | | | | | N/A | ASR Willowbrook | 1996-2000 | | | | | | | | | | | | | 1.78 - 5.42 | 2.86 - 6.83 | | | | 71.2 | 0.007 |
| Water Treatment Plant | | | | | N/A | ASR Willowbrook | 1996-2000 | | | | | | | | | | | | | 0.09 - 1.88 | 1.86 - 3.10 | | | | 80.3 | 0.311 |
| Kennewick Water Distribution System | | | | | N/A | ASR Willowbrook | 10/2/00 | 34 | 11 | 4.4 | 0.53 | 50 | < 2 | 10.4 | 12.5 | < 1 | < 1 | 22.9 | < 1 | | | | | | | |
| Water Distribution System (Reservoir 4) | | | | | N/A | Aspect | 4/26/05 | 5.06 | 5.68 | 6.87 | 2.56 | 20.17 | < 2 | 3.8 | 1.7 | < 1 | 2.7 | 8.2 | 2.4 | 7.55 | 6.15 | 0.228 J | | | 261 U | 2.26 U |
| *Percent Difference in Constituent Concs (Brinkley 17E01 - Reservoir 4)* | | | | | | . | | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | | | | | | | |
| Regional average for Saddle Mountains [(1)] | | | | | N/A | Whiteman | | | | | | | | | | | | | | | | | | | | |
| Regional average for Wanapum [(2)] | | | | | N/A | Whiteman | | | | | | | | | | | | | | | | | | | | |
| Federal MCL[(3)] | | | | | N/A | USEPA | | | | | | | | | | | | | | | | | | | | |
| Federal SMCL [(3)] | | | | | N/A | USEPA | | | | | | | | | | | | | | | | | | | | |
| State MCL [(4)] | | | | | N/A | WAC | | | | | | 80 | | | | | | 60 | | 15 | 50 | 3 | | 5 | 20,000 | 8 |

[1] Mean value based on 131 water analyses (Steinkampf 1989)

[2] Mean value based on 410 water analyses (Steinkampf 1989)

[3] From USEPA 2004 Edition of the Drinking Water Standards and Health Advisories

[4] From WAC 246-290-310

Notes:
Well ID is from the well log or other source, and may not represent current well ownership.
NA: Unreliable reading. NC: Not calculated; at least one value is below detection limit.
Shaded values are above respective MCL concentrations.
U indicates the result is less than the reported detection limit.
J indicates estimated concentration below laboratory detection limit.

## Table 6 Summary of Groundwater Levels Since 1995 for Wells Completed in the Wanapum Formation

| Well Owner | TRS Identifier | X Coord | Y Coord | Elev (ft) | Source | Depth (ft) | Top of Screen (ft) | Bottom of Screen (ft) | Screen Interval | SWL Date | SWL (ft) | SWE (ft) | Yield (gpm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BADGER MOUNTAIN IRRIGATION DIST #2 | 8N/28E-3R01 | 2307239 | 319178 | 709 | ASPECT | 900 | N/A | N/A | Priest Rapids | 1/17/02 | 240.5 | 468.2 | 576 |
| BADGER MOUNTAIN IRRIGATION DIST #4 | 8N/28E-4Q01 | 2300545 | 319005 | 902 | ASPECT | 645 | 585 | 602 | Priest Rapids | 1/17/02 | 468 | 434.2 | 400 |
| GAYLAND BAKER | 8N/28E-13N02 | 2314100 | 309083 | 778 | ECOLOGY | 780 | 565 | 780 | Priest Rapids | 8/3/04 | 459 | 318.5 | 60 |
| LARRY HUTCHISON | 8N/28E-13R01 | 2318084 | 309086 | 928 | ECOLOGY | 766 | 544.5 | 768 | Priest Rapids | 7/29/99 | 485 | 443.5 | 40 |
| MIKE ORIVE | 8N/28E-13R02 | 2318084 | 309086 | 928 | ECOLOGY | 771 | 545 | 771 | Priest Rapids | 1/27/00 | 472 | 456.5 | 40 |
| GREG AND SANDI TRUE | 8N/28E-23D01 | 2308751 | 307702 | 981 | ASPECT | 680 | 580 | 660 | Priest Rapids | 4/7/03 | 480 | 501.0 | 50 |
| HENDERSON | 8N/28E-23N01 | 2308826 | 303731 | 1171 | ECOLOGY | 765 | 710 | 750 | Priest Rapids | 5/31/04 | 495 | 676.2 | 40 |
| MICHAEL CUMMINGS | 8N/28E-23D02 | 2309524 | 307699 | 965 | USGS | 600 | 557 | 600 | Priest Rapids | 3/22/02 | 436 | 528.5 | 200 |
| FRANK RAINE | 8N/29E-17R02 | 2328591 | 308549 | 876 | ASPECT | 715 | 695 | 715 | Priest Rapids | 7/22/99 | 439 | 437.0 | 35 |

# Table 7. Model Results for Different Operational Scenarios

**Lower Ambient Groundwater Velocity**

| Operational Scenario | Recharge | | | Storage | Recovery | | | Estimated Recovery of Stored Water | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time (Days) | Rate (gpm) | Volume (acre-ft) | Days | Time (Days) | Rate (gpm) | Volume (acre-ft) | Recovery % | Recovered (acre-ft) | Unrecovered (acre-ft) |
| 1 | 90 | 800 | 318 | 0 | 60 | 1200 | 318 | 94 | 299 | 19 |
| 2 | 60 | 1200 | 318 | 0 | 60 | 1200 | 318 | 95 | 302 | 16 |
| 3 | 90 | 800 | 318 | 90 | 60 | 1200 | 318 | 89 | 283 | 35 |

**Higher Ambient Groundwater Velocity**

| Operational Scenario | Recharge | | | Storage | Recovery | | | Estimated Recovery of Stored Water | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time (Days) | Rate (gpm) | Volume (acre-ft) | Days | Time (Days) | Rate (gpm) | Volume (acre-ft) | Recovery % | Recovered (acre-ft) | Unrecovered (acre-ft) |
| 4 | 90 | 800 | 318 | 90 | 60 | 1200 | 318 | 4 | 12 | 306 |
| 5* | 90 | 800 | 318 | 90 | 60 | 1200 | 318 | 94 | 298 | 20 |

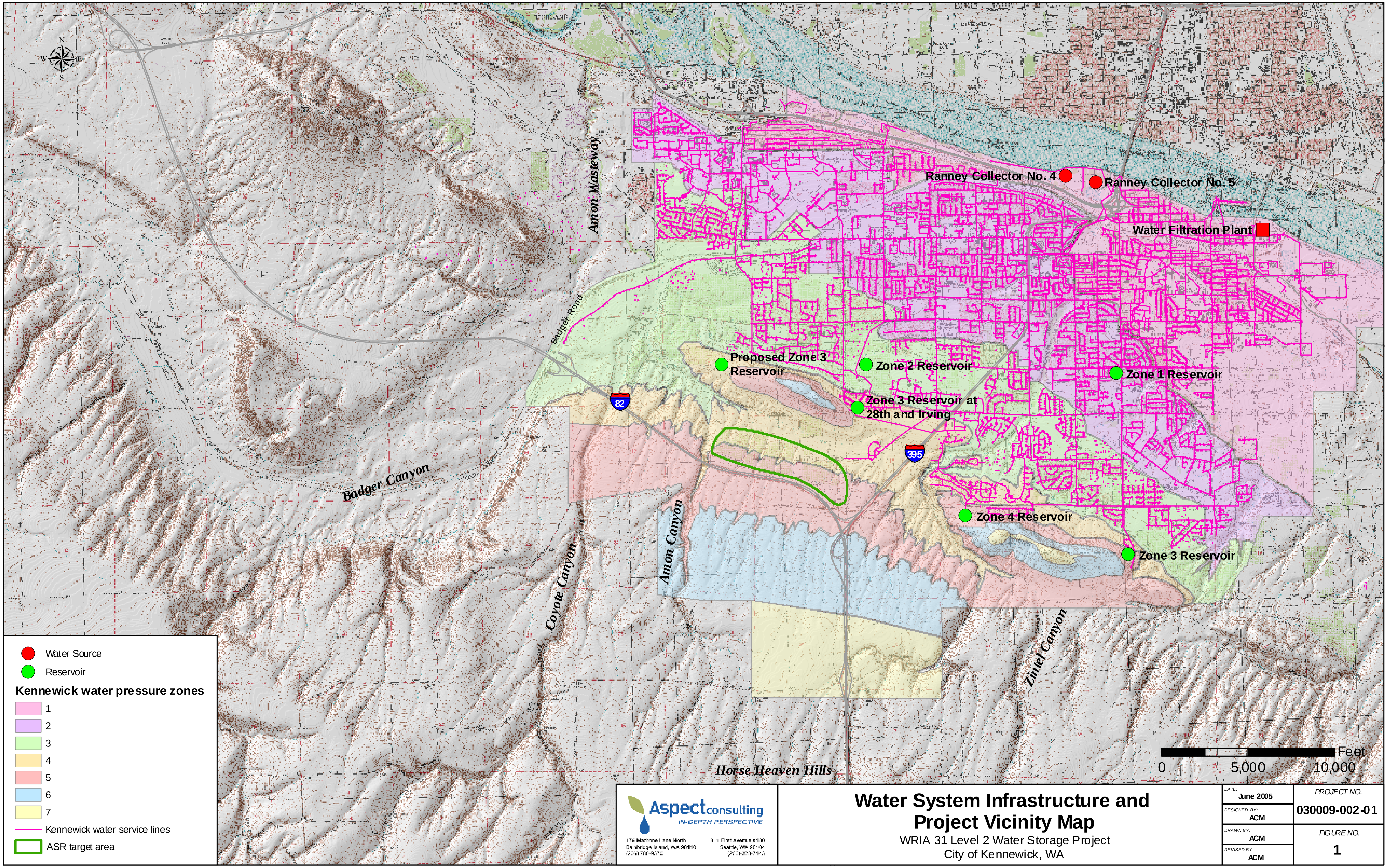
Notes:

* With additional downgradient recovery well

# Table 8. Water Quality Monitoring Schedule for Initial ASR Pilot Test

| | Frequency of Analysis | | | |
|---|---|---|---|---|
| **Stage of Initial Pilot Test** | **Field Parameters** | **General Chemistry/Drinking Water Parameters** | **Prospective Tracers** | **Disinfection Byproducts** |
| **Baseline Testing** | | | | |
| Step Recovery Test | 15 minute interval | 1 time event | 1 time event | 1 time event |
| Step Recharge Test | - | - | - | - |
| **ASR Testing** | | | | |
| Recharge (21 days) | Daily | 7 day interval | 7 day interval | 7 day interval |
| Storage (42 days) | 7 day interval | 14 day interval | 7 day interval | 7 day interval |
| Recovery (28 days) | Daily | 7 day interval | 3 day interval | 3 day interval |
| **Post-ASR Testing** | | | | |
| Step Recovery Test | 15 minute interval | - | - | - |
| Step Recharge Test | - | - | - | - |
| **Constituents** | Temperature<br>pH<br>Dissolved Oxygen<br>Redox Potential<br>Specific Conductivity<br>Turbidity<br>Methane<br>Hydrogen Sulfide | General Chemistry<br>Alkalinity<br>TDS<br>TSS**<br>Silica<br>Total Organic Carbon<br>Major Cations<br>Calcium<br>Magnesium<br>Potassium<br>Sodium<br>Major Anions<br>Bicarbonate<br>Chloride<br>Sulfate<br>Additional Anions<br>Bromide<br>Fluoride<br>Nitrate-N<br>Nitrite-N<br>Metals<br>Arsenic<br>Antimony<br>Aluminum<br>Barium<br>Beryllium<br>Cadmium<br>Chromium<br>Copper<br>Iron<br>Lead<br>Manganese<br>Mercury<br>Nickel<br>Selenium<br>Silica<br>Silver<br>Thallium<br>Zinc | Inorganics<br>Barium<br>Fluoride<br>Nitrate<br>Silica<br>(others/different may be determined based on baseline well testing; refer to text) | Trihalomethanes (THMs)<br>Chloroform<br>Bromoform<br>Bromodichloromethane<br>Dibromochloromethane<br>Haloacetic Acids (HAAs)<br>Monochloroacetic Acid<br>Dichloroacetic Acid<br>Trichloroacetic Acid<br>Monobromoacetic Acid<br>Dibromoacetic Acid<br>Bromochloroacetic Acid<br>Residual Chlorine |

**: TSS will be analyzed daily throughout the recharge period.



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[illegible]

[illegible]

## Water System Infrastructure and Project Vicinity Map

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

| | |
|---|---|
| DATE: June 2005 | PROJECT NO. 030009-002-01 |
| DESIGNED BY: ACM | |
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| REVISED BY: ACM | |

| PERIOD | EPOCH | GROUP | SUBGROUP | FORMATION | K-Ar AGE YEARS x $10^6$ | MEMBER OR SEQUENCE | GEOLOGIC MAPPING SYMBOL | SEDIMENT STRATIGRAPHY, OR FLOWS OR BEDS | |
|---|---|---|---|---|---|---|---|---|---|
| QUATERNARY | Pleistocene / Holocene | | | | | SURFICIAL UNITS | Ql | LOESS | |
| | | | | | | | Qd | SAND DUNES | |
| | | | | | | | Qa,Qaf | ALLUVIUM & ALLUVIAL FANS | |
| | | | | | | | Qld | LANDSLIDES | |
| | | | | | | | Qt | TALUS | |
| | | | | | | | Qco | COLLUVIUM | |
| | Pleisto-cene | | | Hanford | | TOUCHET BEDS/ PASCO GRAVELS | Qht/Qhp | | |
| TERTIARY | Pliocene | | | Ringold | | | Trs | UPPER RINGOLD | RINGOLD FAN-GLOM-ERATE |
| | | | | | | | Trc | MIDDLE RINGOLD | |
| | | | | | | | Trls | LOWER RINGOLD | |
| | | | | | | | Trg | BASAL RINGOLD | |
| | Miocene | Columbia River Basalt Group | Yakima Basalt Subgroup | Saddle Mountains Basalt | 8.5 | ICE HARBOR MEMBER | Ti: Tig | GOOSE ISLAND FLOW | ELLENSBURG FORMATION Tel |
| | | | | | | | Tim | MARTINDALE FLOW | |
| | | | | | | | Tib | BASIN CITY FLOW | |
| | | | | | | | | LEVEY INTERBED | |
| | | | | | 10.5 | ELEPHANT MOUNTAIN MEMBER | Tem: $Tem_2$ | UPPER ELEPHANT MTN FLOW | |
| | | | | | | | $Tem_1$ | LOWER ELEPHANT MTN FLOW | |
| | | | | | | | | RATTLESNAKE RIDGE INT. | |
| | | | | | 12.0 | POMONA MEMBER | Tp: $Tp_2$ | UPPER POMONA FLOW | |
| | | | | | | | $Tp_1$ | LOWER POMONA FLOW | |
| | | | | | | | | SELAH INTERBED | |
| | | | | | | ESQUATZEL MEMBER | Te: $Te_2$ | UPPER GABLE MTN FLOW | |
| | | | | | | | | GABLE MTN INTERBED | |
| | | | | | | | $Te_1$ | LOWER GABLE MTN FLOW | |
| | | | | | | | | COLD CREEK INTERBED | |
| | | | | | | ASOTIN MEMBER | Ta | HUNTZINGER FLOW | |
| | | | | | | WILBUR CREEK MEMBER | Tw | WAHLUKE FLOW | |
| | | | | | | UMATILLA MEMBER | Tu: $Tu_s$ | SILLUSI FLOW | |
| | | | | | | | $Tu_u$ | UMATILLA FLOW | |
| | | | | | | | | MABTON INTERBED | |
| | | | | Wanapum Basalt | 13.6 | PRIEST RAPIDS MEMBER | Tpr: $Tpr_l$ | LOLO FLOW | |
| | | | | | | | $Tpr_r$ | ROSALIA FLOWS | |
| | | | | | | | | QUINCY INTERBED | |
| | | | | | | ROZA MEMBER | Tr: $Tr_2$ | UPPER ROZA FLOW | |
| | | | | | | | $Tr_1$ | LOWER ROZA FLOW | |
| | | | | | | | | SQUAW CREEK INTERBED | |
| | | | | | | FRENCHMAN SPRINGS MEMBER | Tf: $Tf_a$ | APHYRIC FLOWS | |
| | | | | | | | $Tf_p$ | PHYRIC FLOWS | |
| | | | | | | | | VANTAGE INTERBED | |
| | | | | Grande Ronde Basalt | 14.5 | SENTINEL BLUFFS SEQUENCE | Tsb | UPPER Cr FLOWS | |
| | | | | | | | | INTERMEDIATE Cr FLOWS | |
| | | | | | | | | LOWER Cr FLOWS | |
| | | | | | | | | McCOY CANYON FLOW | |
| | | | | | | SCHWANA SEQUENCE | Ts | INTERMEDIATE-Mg FLOW | |
| | | | | | | | | LOW-Mg FLOW ABOVE UMTANUM | |
| | | | | | | | | UMTANUM FLOW | |
| | | | | | | | | HIGH-Mg FLOW BELOW UMTANUM | |
| | | | | | | | | VERY HIGH-Mg FLOWS | |
| | | | | | 16.5 | | | AT LEAST 30 LOW-Mg FLOWS | |

From Myers and Price (1981)

RCP8108-1

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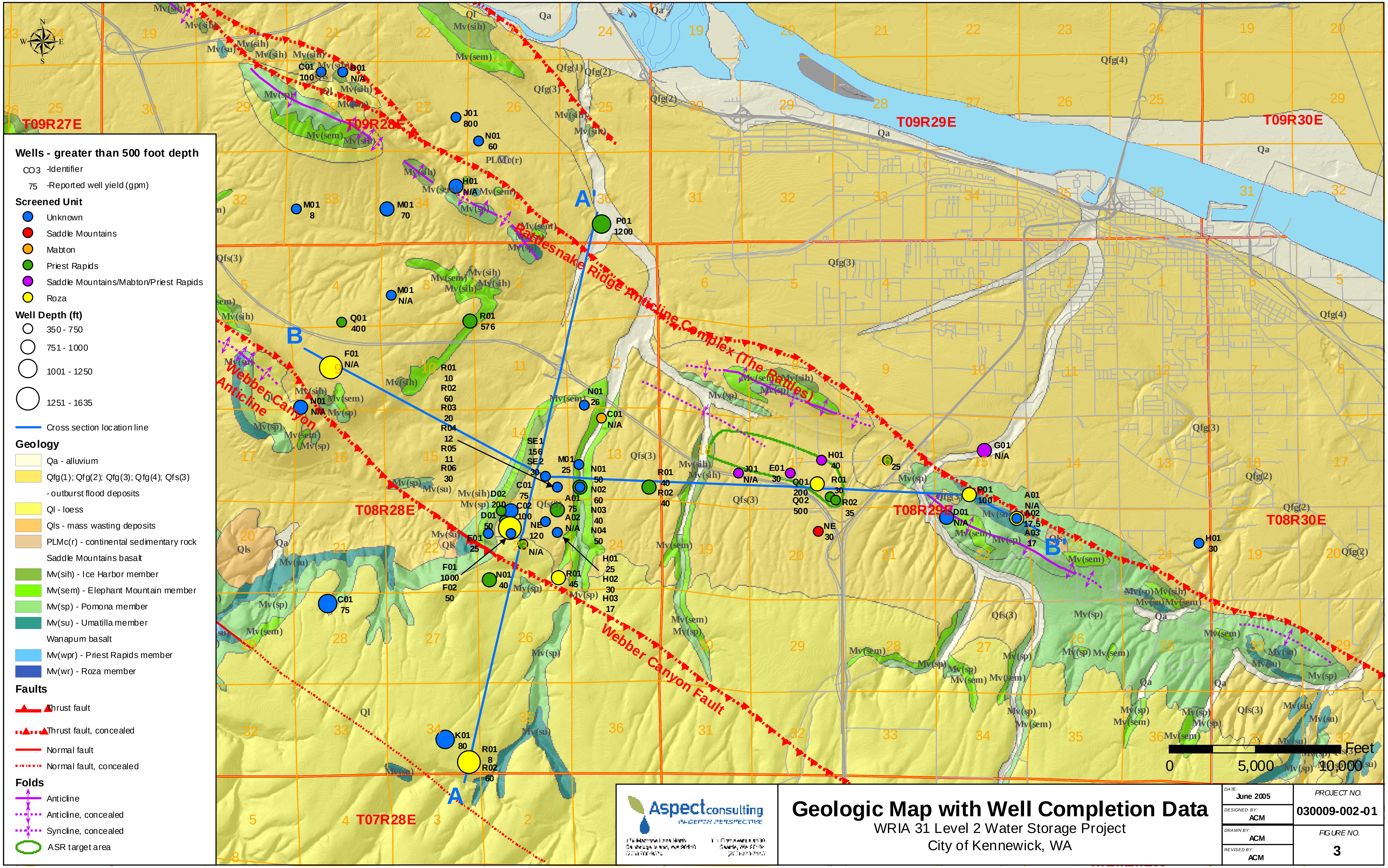
# Stratigraphic Units of the Columbia River Basalt Group

WRIA 31 Level 2 Storage Project
City of Kennewick, Washington

DATE: June 2005
DESIGNED BY: JMS
DRAWN BY: PMB
REVISED BY: -

PROJECT NO. 030009
FIGURE NO. 2

Q:\WRIA\030009 WRIA 31\2005-06 ASR\030009-02.dwg



**Wells - greater than 500 foot depth**

CO3 -Identifier
75 -Reported well yield (gpm)

**Screened Unit**

- 🔵 Unknown
- 🔴 Saddle Mountains
- 🟠 Mabton
- 🟢 Priest Rapids
- 🟣 Saddle Mountains/Mabton/Priest Rapids
- 🟡 Roza

**Well Depth (ft)**

- ○ 350 - 750
- ○ 751 - 1000
- ○ 1001 - 1250
- ○ 1251 - 1635

Cross section location line

**Geology**

- ▨ Qa - alluvium
- ▨ Qfg(1); Qfg(2); Qfg(3); Qfg(4); Qfs(3) - outburst flood deposits
- ▨ Ql - loess
- ▨ Qls - mass wasting deposits
- ▨ PLMc(r) - continental sedimentary rock

Saddle Mountains basalt

- ▨ Mv(sih) - Ice Harbor member
- ▨ Mv(sem) - Elephant Mountain member
- ▨ Mv(sp) - Pomona member
- ▨ Mv(su) - Umatilla member

Wanapum basalt

- ▨ Mv(wpr) - Priest Rapids member
- ▨ Mv(wr) - Roza member

**Faults**

- Thrust fault
- Thrust fault, concealed
- Normal fault
- Normal fault, concealed

**Folds**

- Anticline
- Anticline, concealed
- Syncline, concealed
- ASR target area

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# Geologic Map with Well Completion Data

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

| | |
|---|---|
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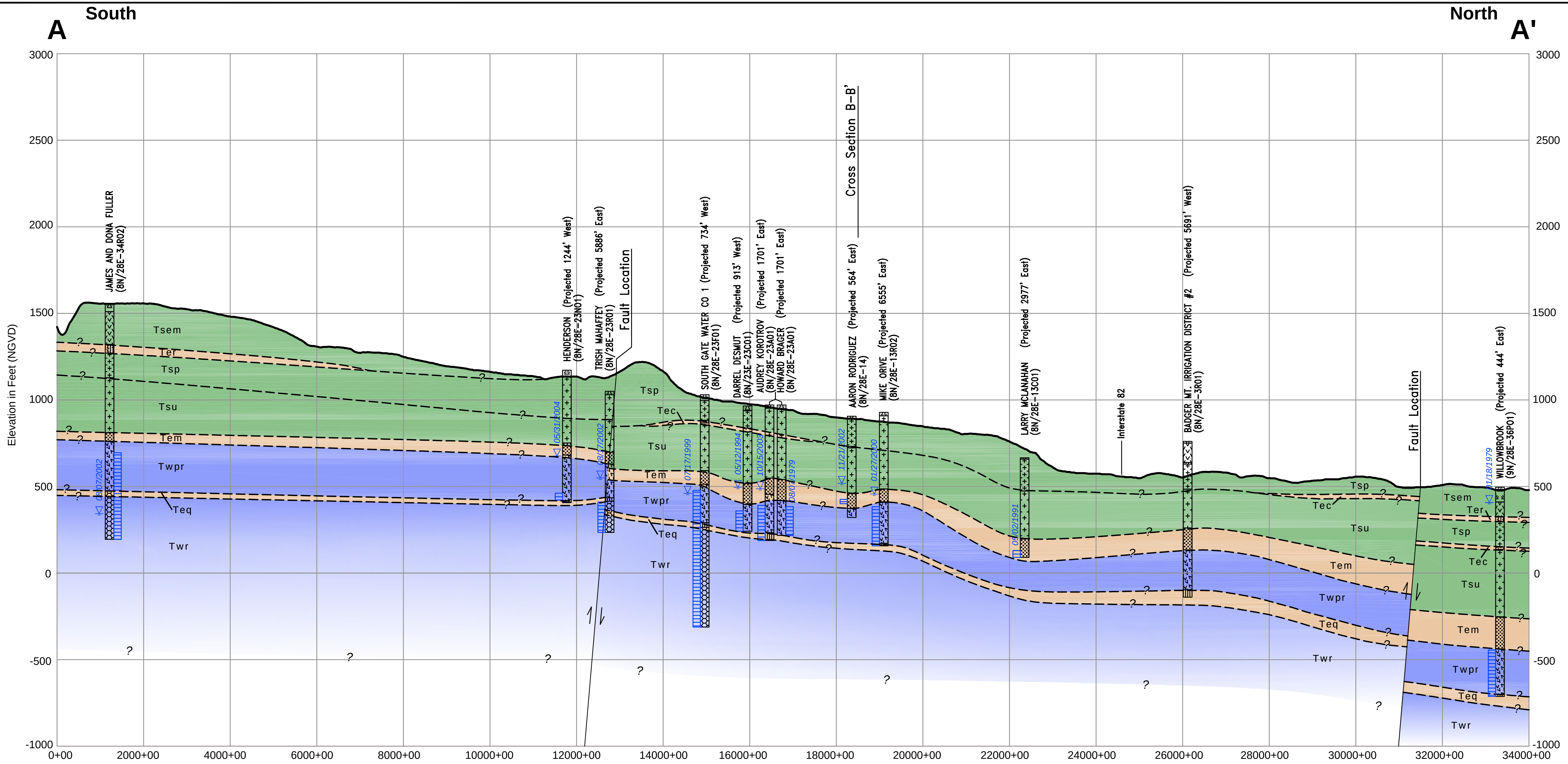

Vertical Exaggeration = 4X
Scale: 1" = 2000' Horiz.
1" = 500' Vert.

Horizontal Scale
0 2000 4000
Feet

## LEGEND

**Quarternary Sediments**
- ▨ Qa Unconsolidated Sediments

**Ellensburg Formation**
- ▨ Tel Levey Member
- ▨ Ter Rattlesnake Ridge Member
- ▨ Tec Cold Creek Member
- ▨ Tem Mabton Member
- ▨ Teq Quincy Member

**Saddle Mountain Formation**
- ▨ Tsih Ice Harbor Member
- ▨ Tsem Elephant Mtn Member
- ▨ Tsp Pomona and Esquatzel Members
- ▨ Tsu Umatilla Member

**Wanapum Formation**
- ▨ Twpr Priest Rapids Member
- ▨ Twr Roza Member

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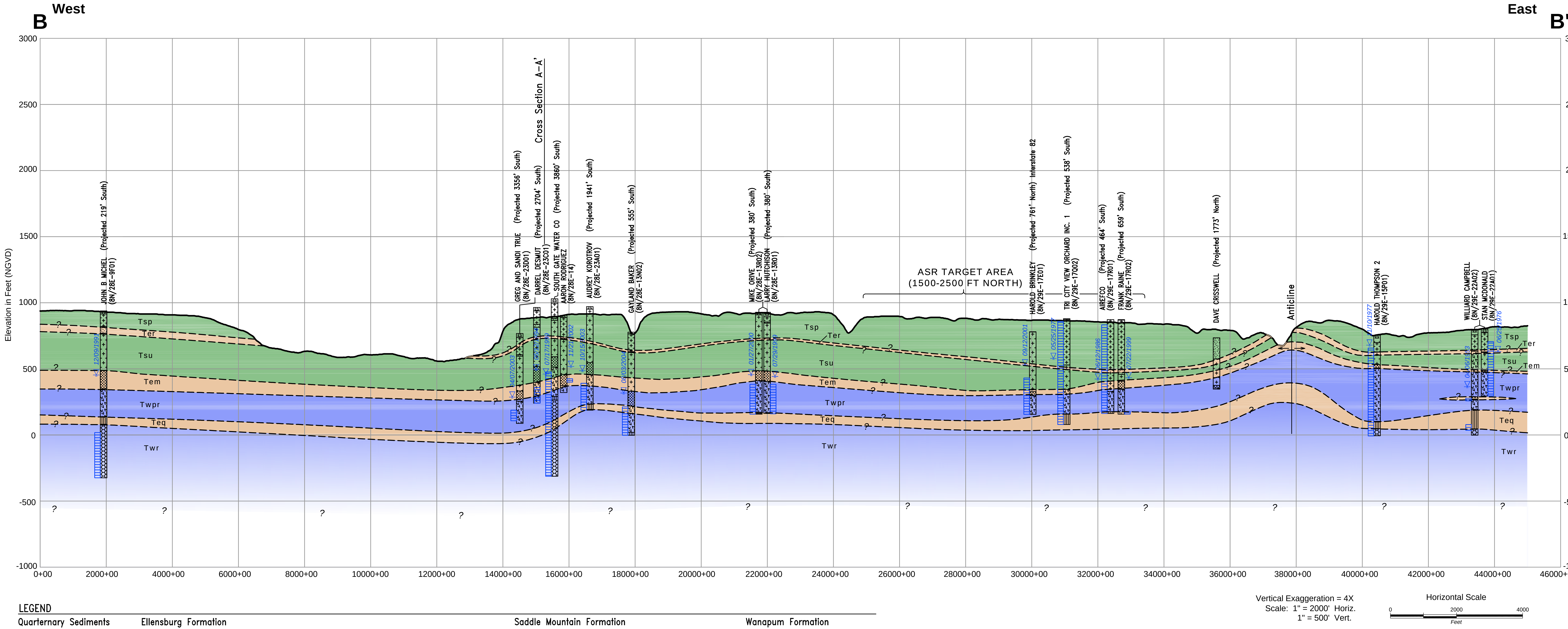
# Cross Section A-A'

WRIA 31 Level 2 Water Storage Project
City of Kennewick, Washington

| | |
|---|---|
| DATE: June 2005 | PROJECT NO. 030009 |
| DESIGNED BY: JMS | |
| DRAWN BY: PMB | FIGURE NO. 4 |
| REVISED BY: PMB (May 2005) | |

Q:\WRIA\030009 WRIA 31\2005-06 ASR\030009-AA.dwg



## LEGEND

**Quarternary Sediments**
- Qa Unconsolidated Sediments

**Ellensburg Formation**
- Tel Levey Member
- Ter Rattlesnake Ridge Member
- Tec Cold Creek Member
- Tem Mabton Member
- Teq Quincy Member

**Saddle Mountain Formation**
- Tsih Ice Harbor Member
- Tsem Elephant Mtn Member
- Tsp Pomona and Esquatzel Members
- Tsu Umatilla Member

**Wanapum Formation**
- Twpr Priest Rapids Member
- Twr Roza Member

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## Cross Section B-B'

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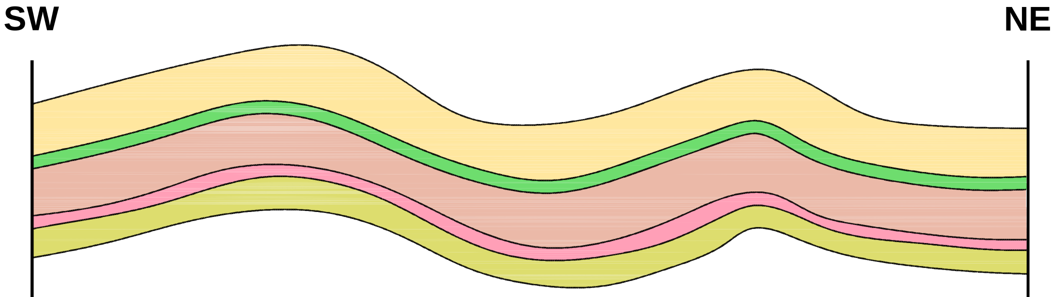
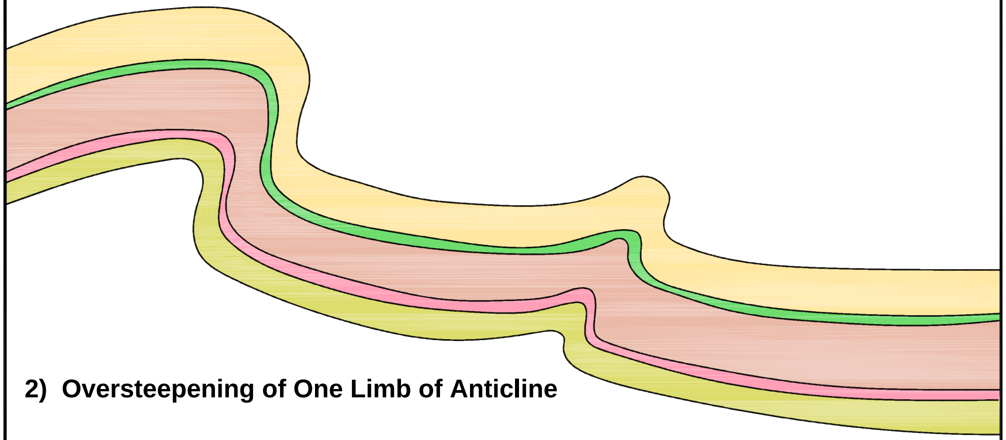
City of Kenniwick, Washington

| | |
|---|---|
| DATE: June 2005 | PROJECT NO. 030009 |
| DESIGNED BY: JMS | |
| DRAWN BY: PMB | FIGURE NO. 5 |
| REVISED BY: PMB (May 2005) | |

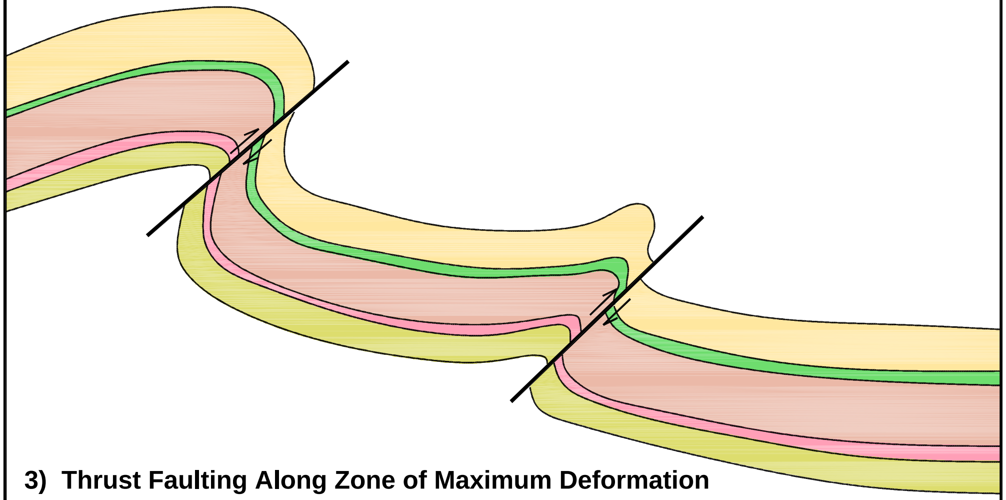
Q:\WRIA\030009 WRIA 31\2005-06 ASR\030009-BB.dwg



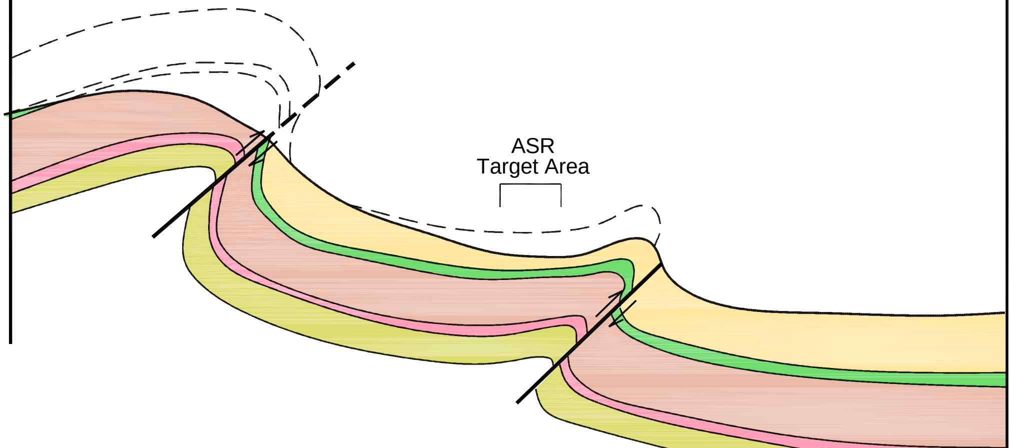
1) Folding Under Compression



2) Oversteepening of One Limb of Anticline



3) Thrust Faulting Along Zone of Maximum Deformation



NOT TO SCALE

4) Erosion Exposing Interior of Faulted Anticlines
(Dashed Lines Show Eroded Strata)

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# Schematic Structural Evolution of Rattlesnake Ridge Anticline Complex

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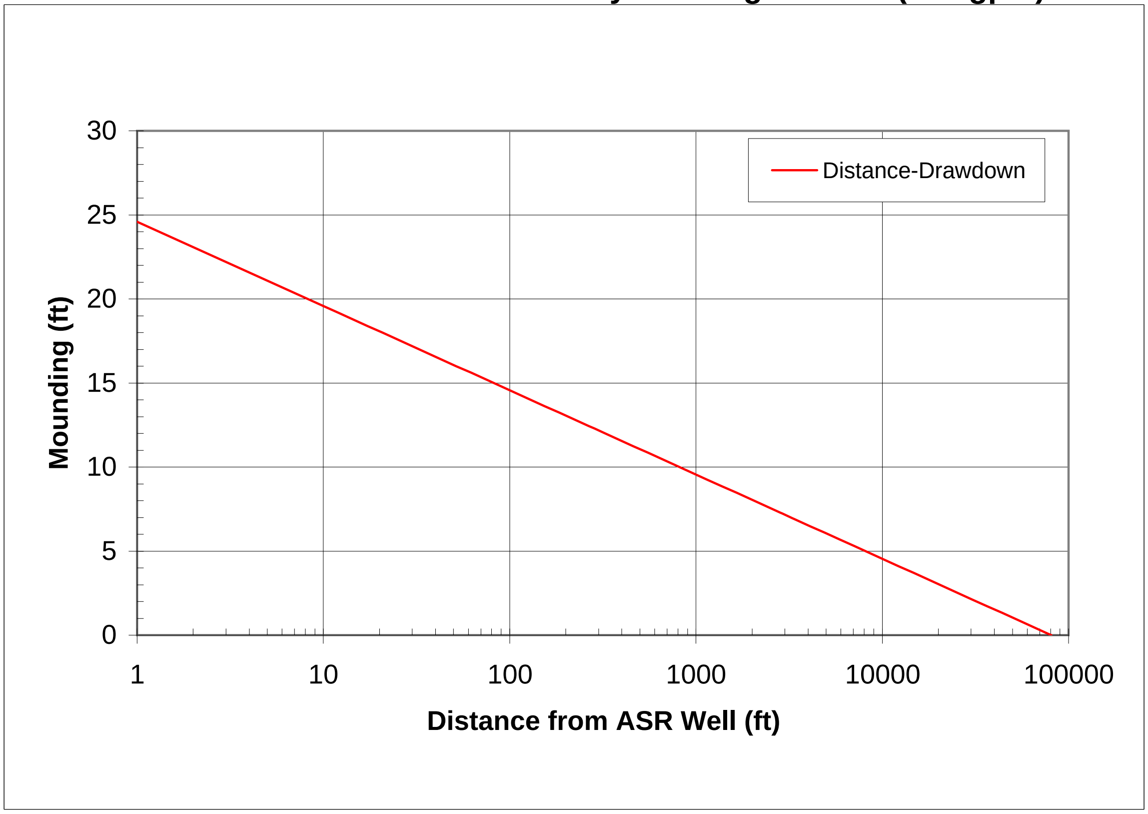
City of Kennewick, Washington

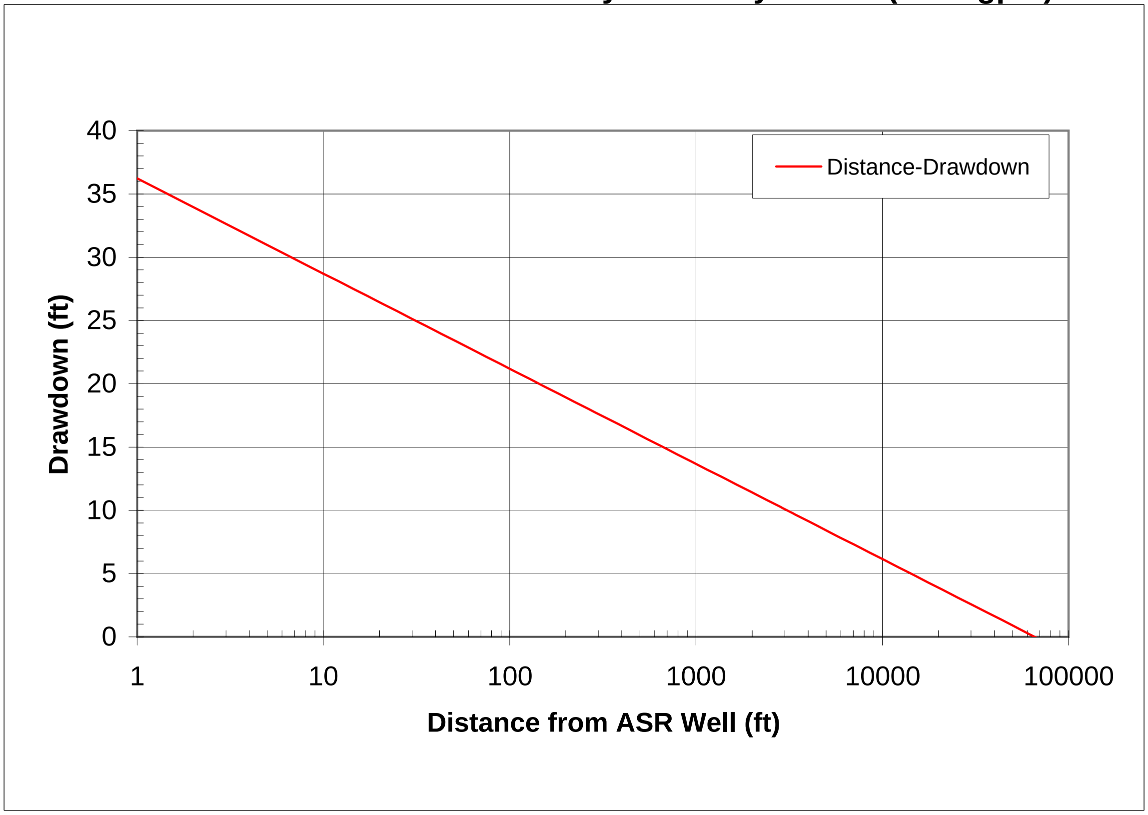
| | |
|---|---|
| DATE: | June 2005 |
| DESIGNED BY: | DHM |
| DRAWN BY: | JRS |
| REVISED BY: | |
| PROJECT NO. | 030009 |
| FIGURE NO. | 6 |

Q:\WRIA\030009 WRIA 31\2005-06 ASR\030009-03.dwg

Distance-Drawdown Plot of 90-day Recharge Period (800 gpm)



Distance-Drawdown Plot of 60-day Recovery Period (1200 gpm)



# Distance-Drawdown
# Curve for Hypothetical ASR Well

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

**Figure 7**

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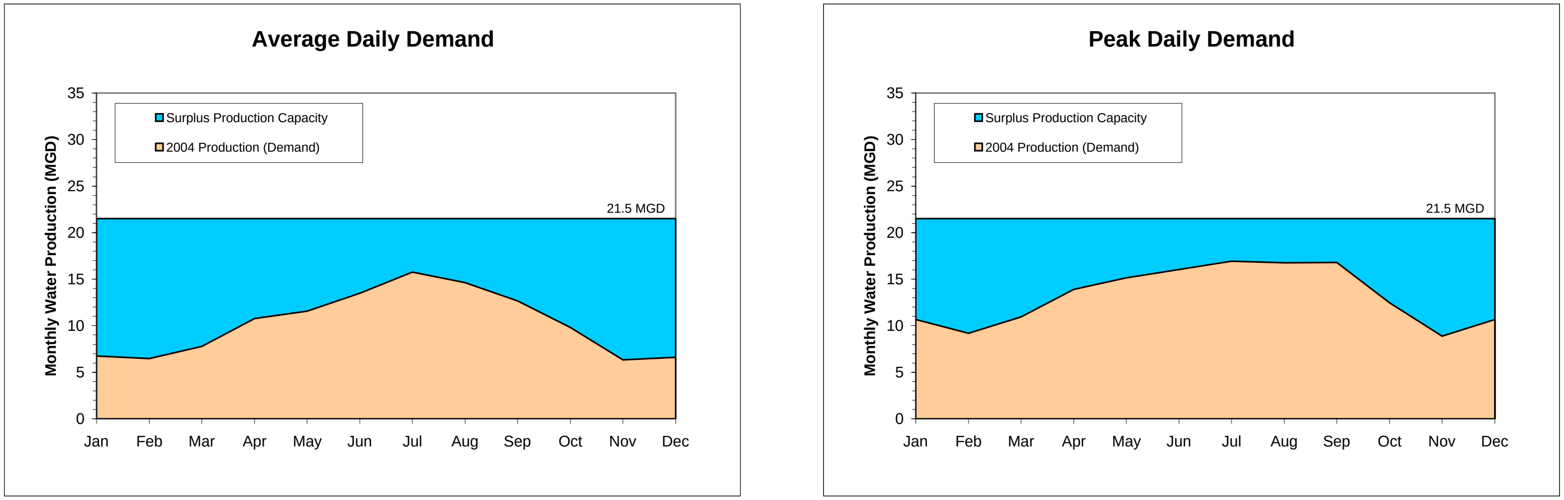
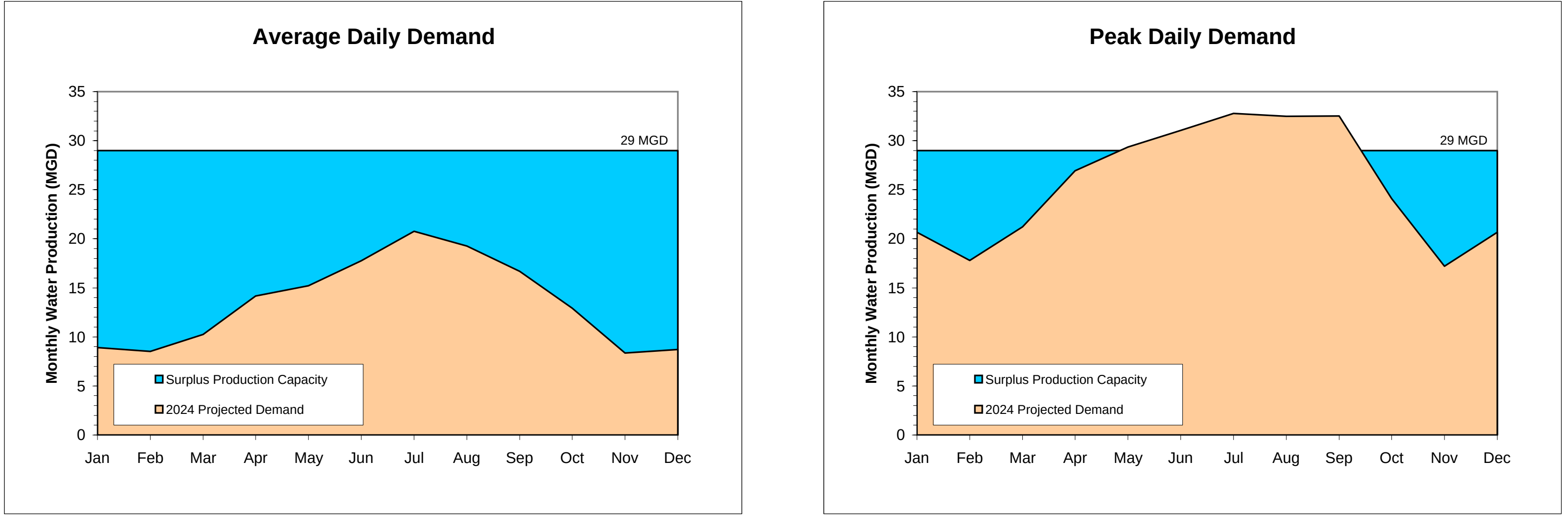
V:\030009 WRIA 31\ASR Report\Hydraulic Parameters.xls - Figure 7

## 2004 Actual Water Production



## 2024 Projected Water Production



Projected demands exclude additional major industrial use.
Projected capacity assumes no additional source capacity beyond current surface water treatment upgrade is developed by 2024.

---

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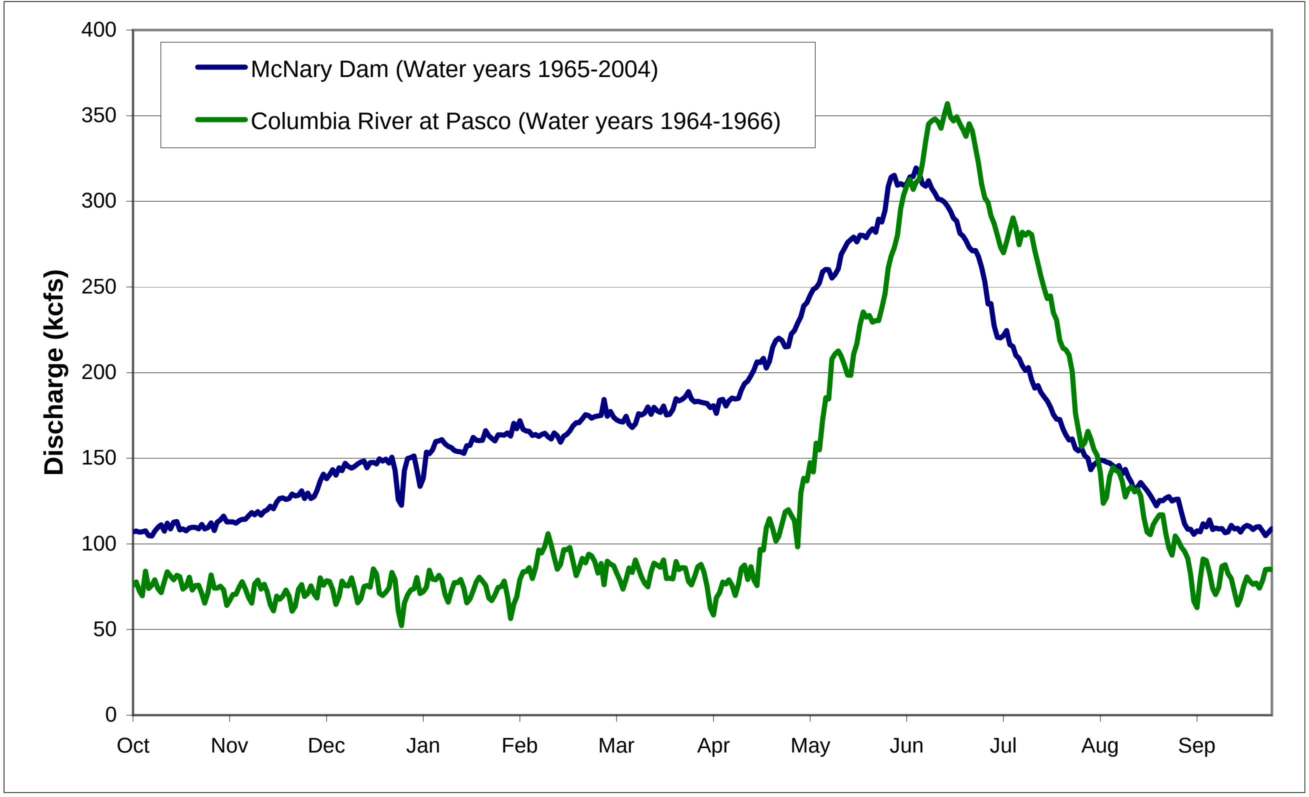
V:\030009 WRIA 31\ASR Report\Kennewick Seasonal Supply-Demand.xls - Fig 8 - Demand vs Capacity

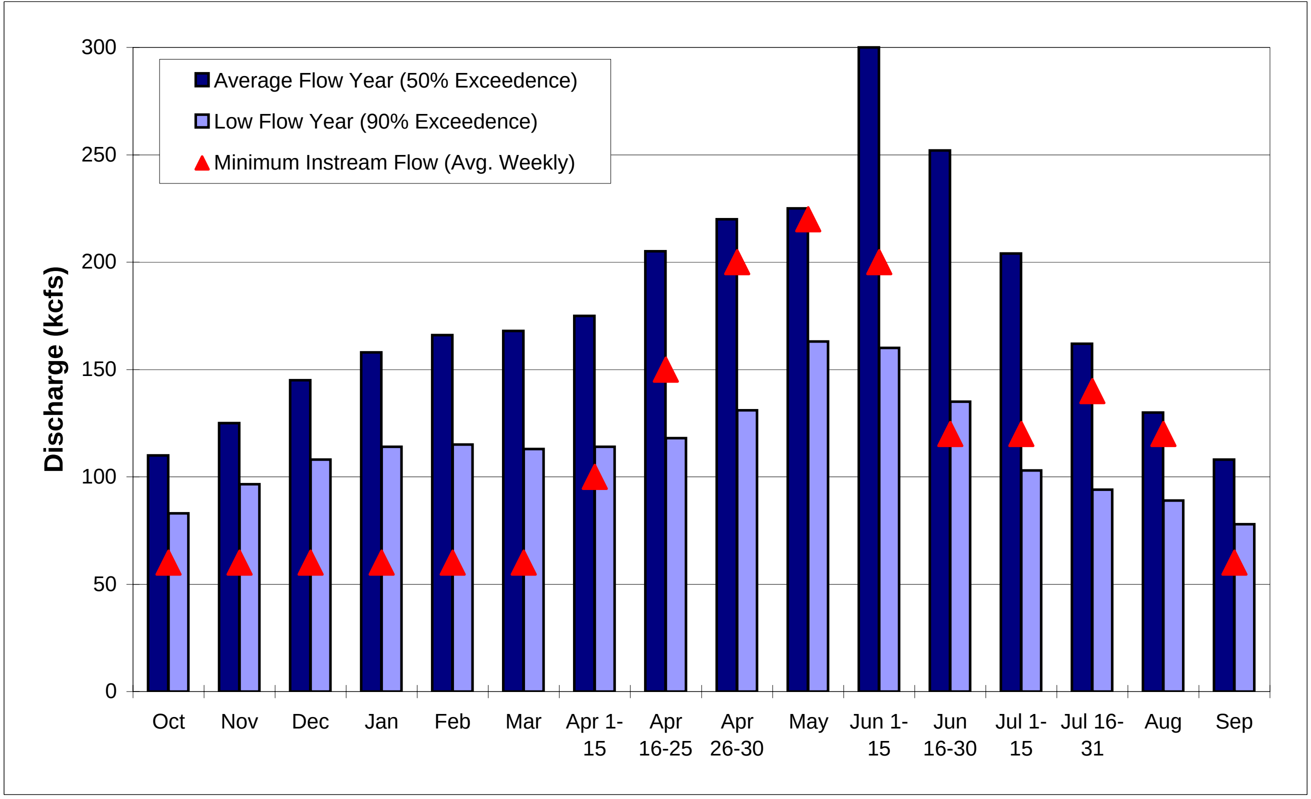
**2004 Actual and 2024**
**Projected Water Demand vs. Capacity**
WRIA 31 Level 2 Water Storage Assessment
Kennewick, WA

**Figure 8**

## Mean Daily Flows for McNary Dam and the Columbia River at Pasco



## Exceedance Flows and Minimum Instream Flow Requirements for McNary Dam

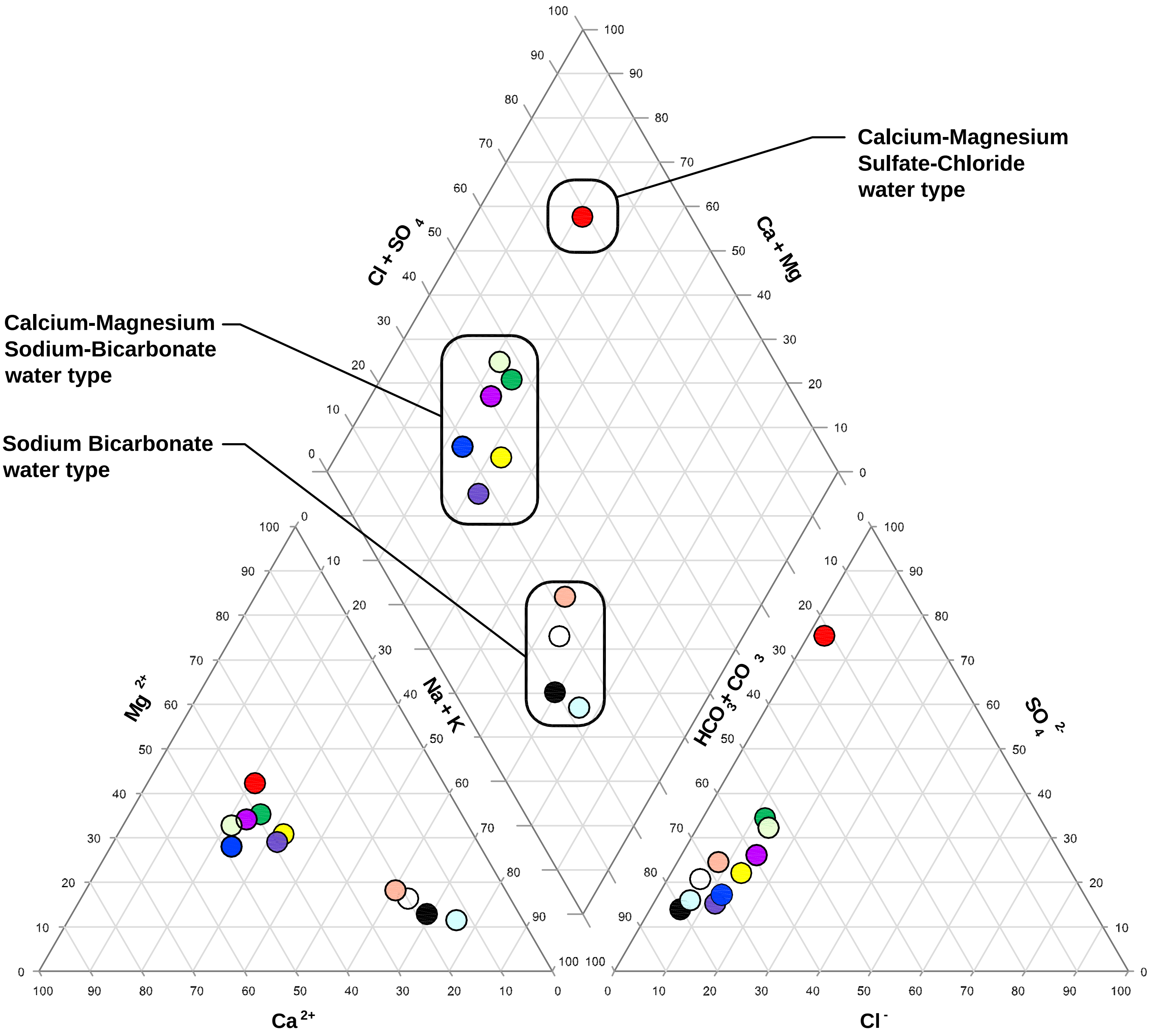


**Flow Data for Columbia River Near Kennewick**

WRIA 31 Level 2 Water Storage Project

City of Kennewick, WA

**Figure 9**



Calcium-Magnesium
Sulfate-Chloride
water type

Calcium-Magnesium
Sodium-Bicarbonate
water type

Sodium Bicarbonate
water type

# LEGEND

## HISTORICAL WATER QUALITY DATA

- ⚫ **JOHN B. MICHEL (8N/28E-9F01) 9/5/01**
- ⚪ **HAROLD BRINKLEY (8N/29E-17Q01) 2/18/88**
- 🔴 **WILLIARD CAMPBELL (8N/29E-22A02) 11/17/70**
- 🟢 **FRANK STAPLES (9N/28E-27J01) 6/24/82**
- 🟡 **SADDLE MOUNTAINS FORMATION**
- 🟣 **WANAPUM FORMATION**

## APRIL 2005 WATER QUALITY DATA

- 🟣 **BRINKLEY (8N/29E-17Q01) 4/26/05**
- 🔵 **RESERVOIR4 4/26/05**
- ⚪ **THOMPSON1 (8N/29E-15G01) 4/26/05**
- ⚪ **GILLIAM (8N/29E-15G01) 4/27/05**
- 🟠 **TRUE (8N/28E-23D01) 4/27/05**

NOTE:
Saddle Mountain and Wanapum groundwater compositions
are mean compositions from Steinkampf (1989).

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## Piper Diagram Illustrating Groundwater Chemistry Types

WRIA 31 Level 2 Water Storage Project
City of Kennewick, Washington

| | |
|---|---|
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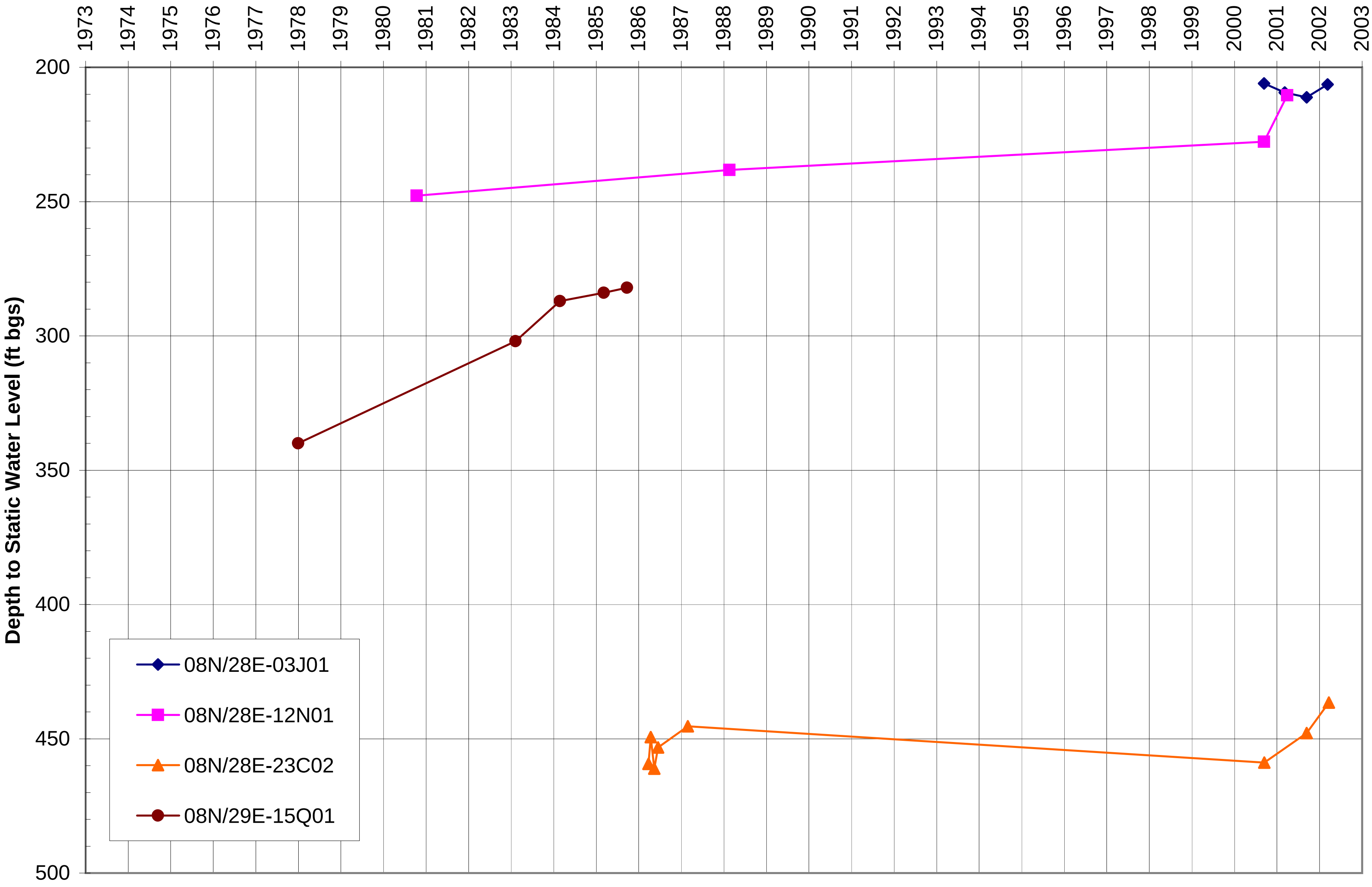
| DESIGNED BY: | JMS |
| DRAWN BY: | PMB |
| REVISED BY: | |

PROJECT NO.
030009

FIGURE NO.
10

Q:\WRIA\030009 WRIA 31\2005-06 ASR\030009-04.dwg



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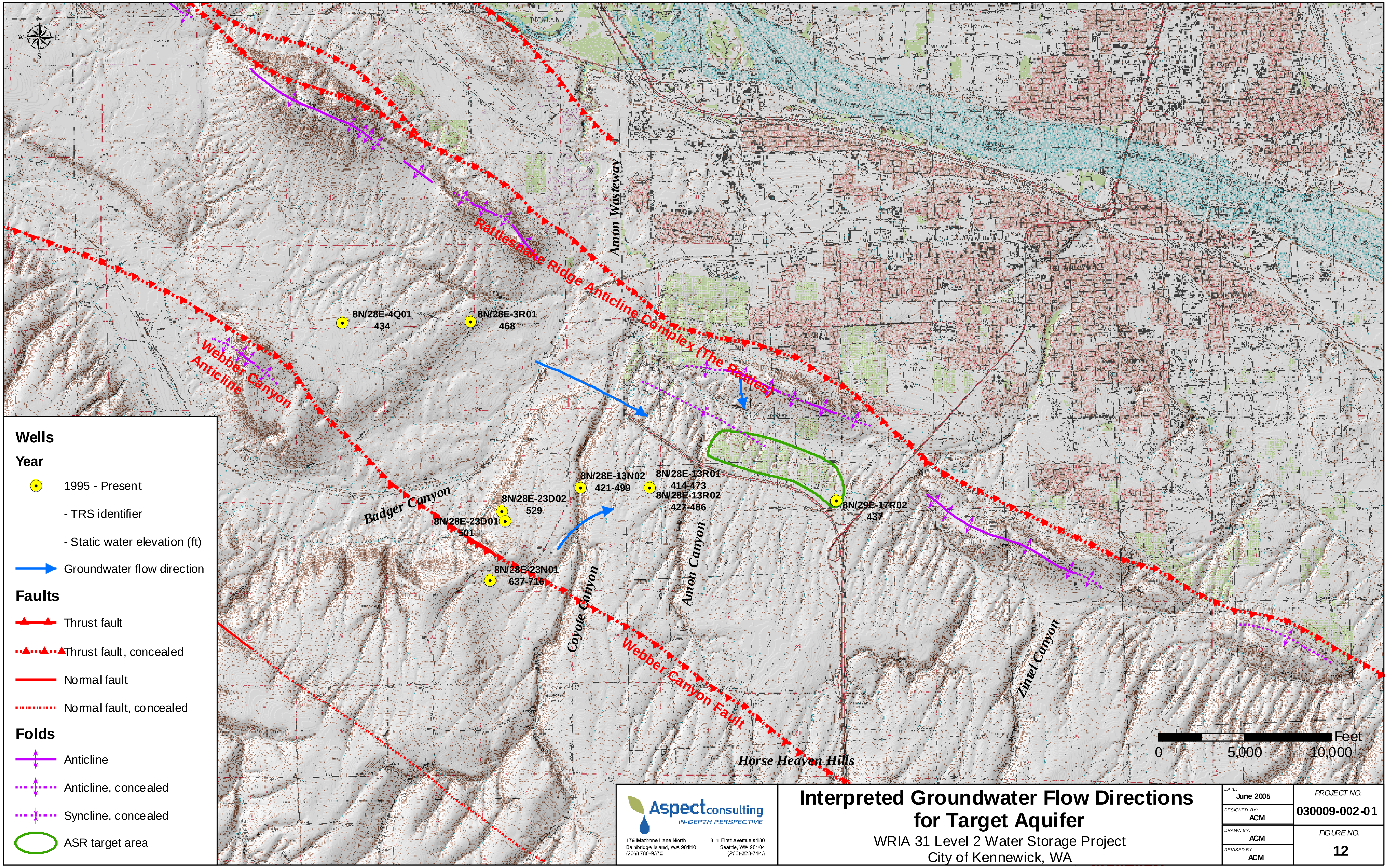
# Hydrographs of USGS Monitored Wells in Project Area

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

**Figure 11**

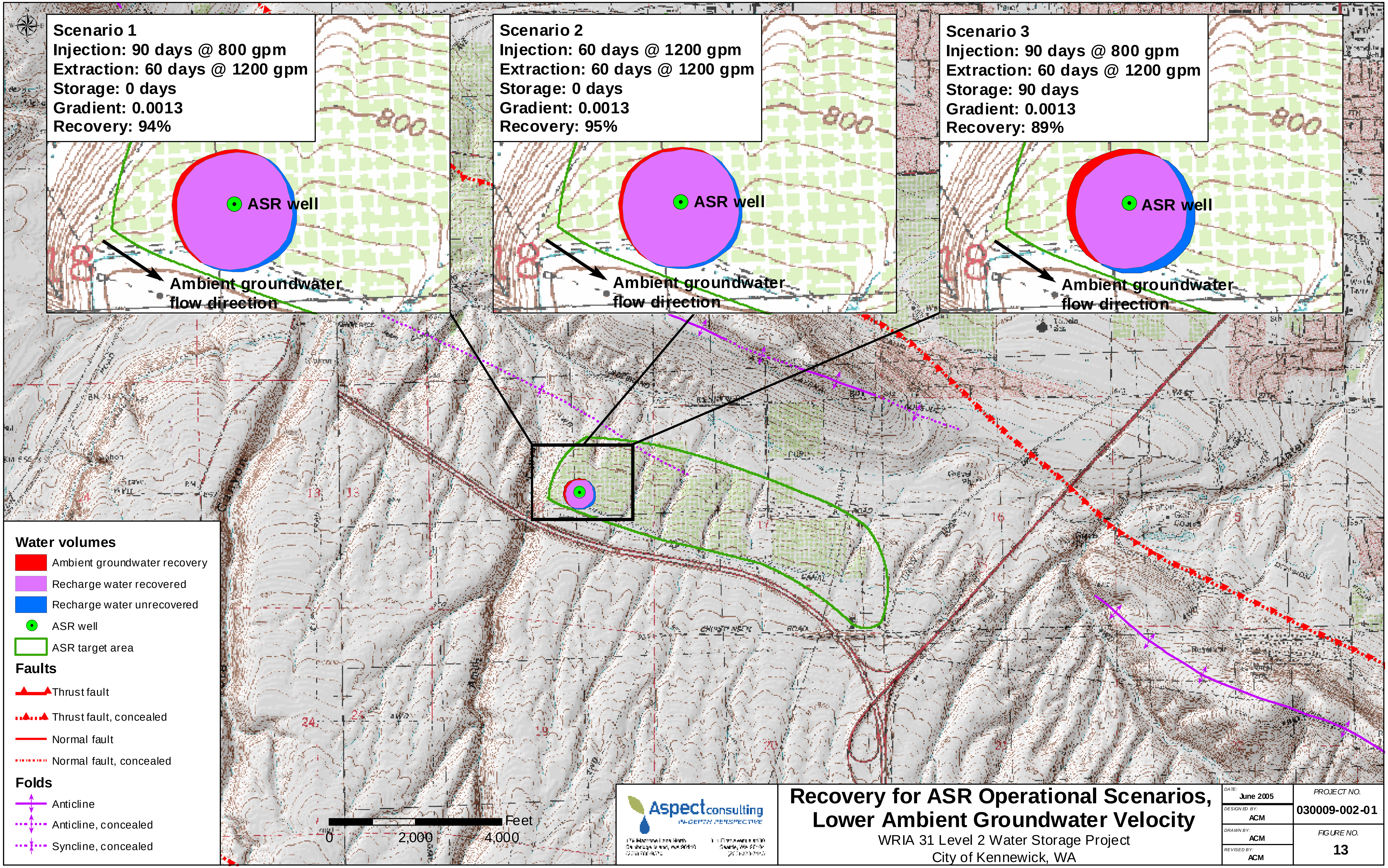
V:\030009 WRIA 31\ASR Report\Static Water Levels.xls - Fig 11 - Hydrograph



# Interpreted Groundwater Flow Directions for Target Aquifer

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

DATE: June 2005
DESIGNED BY: ACM
DRAWN BY: ACM
REVISED BY: ACM
PROJECT NO. 030009-002-01
FIGURE NO. 12



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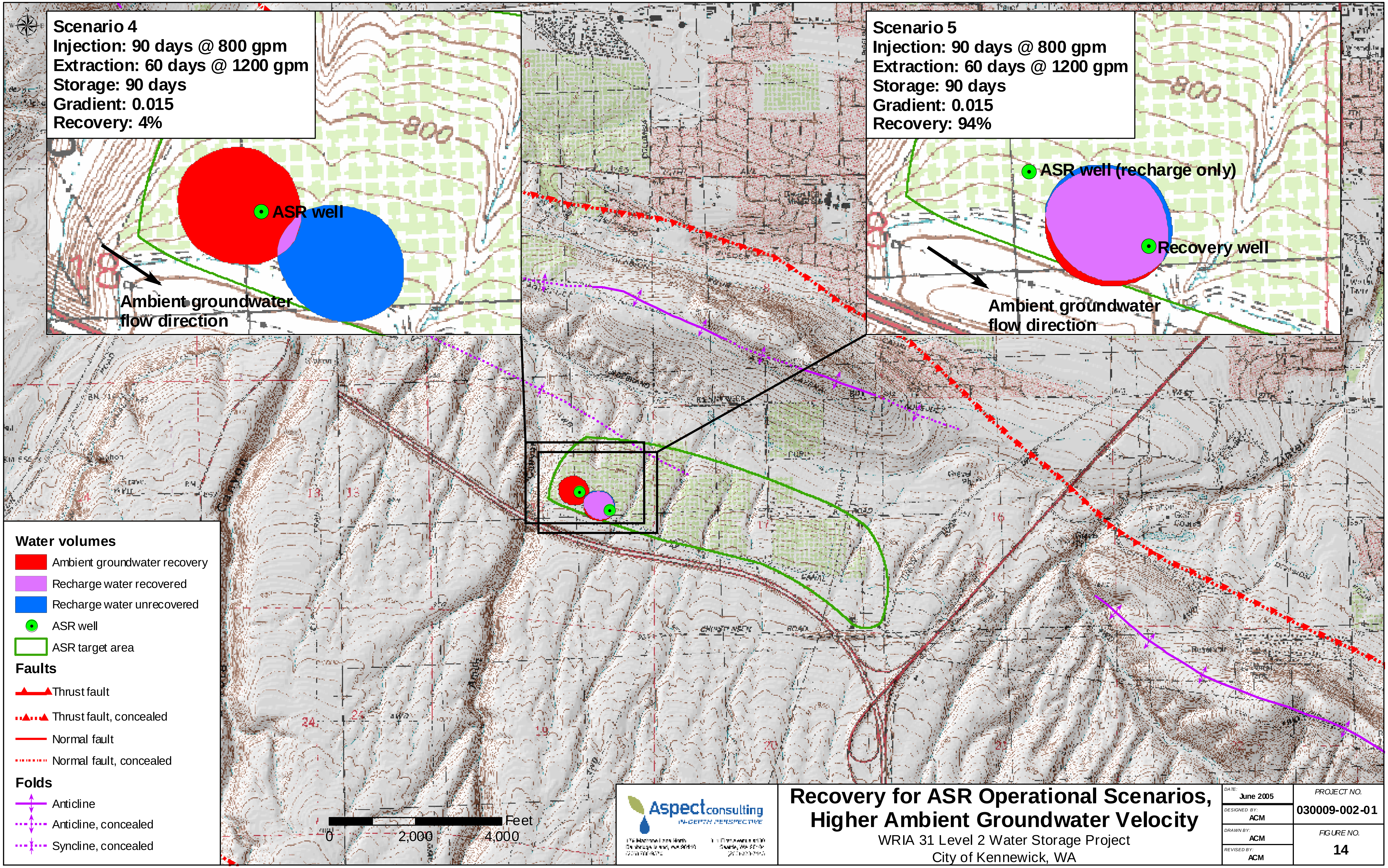
# Recovery for ASR Operational Scenarios, Lower Ambient Groundwater Velocity

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

| | |
|---|---|
| DATE: June 2005 | PROJECT NO. 030009-002-01 |
| DESIGNED BY: ACM | |
| DRAWN BY: ACM | FIGURE NO. 13 |
| REVISED BY: ACM | |



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# Recovery for ASR Operational Scenarios, Higher Ambient Groundwater Velocity

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

DATE: June 2005
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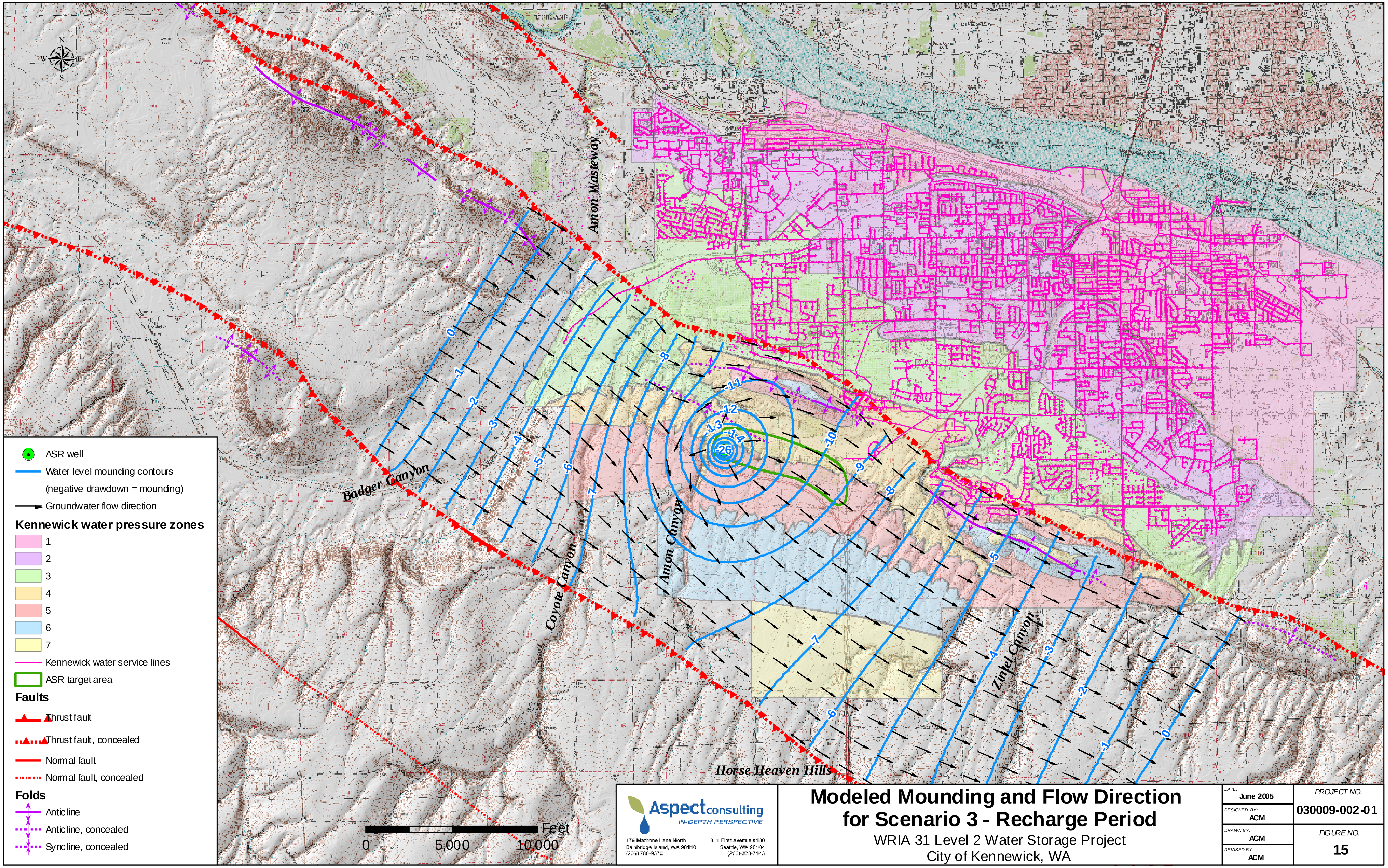
REVISED BY: ACM

PROJECT NO.
030009-002-01

FIGURE NO.
14



● ASR well

Water level mounding contours

(negative drawdown = mounding)

Groundwater flow direction

**Kennewick water pressure zones**

| | |
|---|---|
| 🟥 | 1 |
| 🟪 | 2 |
| 🟩 | 3 |
| 🟧 | 4 |
| 🟥 | 5 |
| 🟦 | 6 |
| 🟨 | 7 |

Kennewick water service lines

ASR target area

**Faults**

Thrust fault

Thrust fault, concealed

Normal fault

Normal fault, concealed

**Folds**

Anticline

Anticline, concealed

Syncline, concealed

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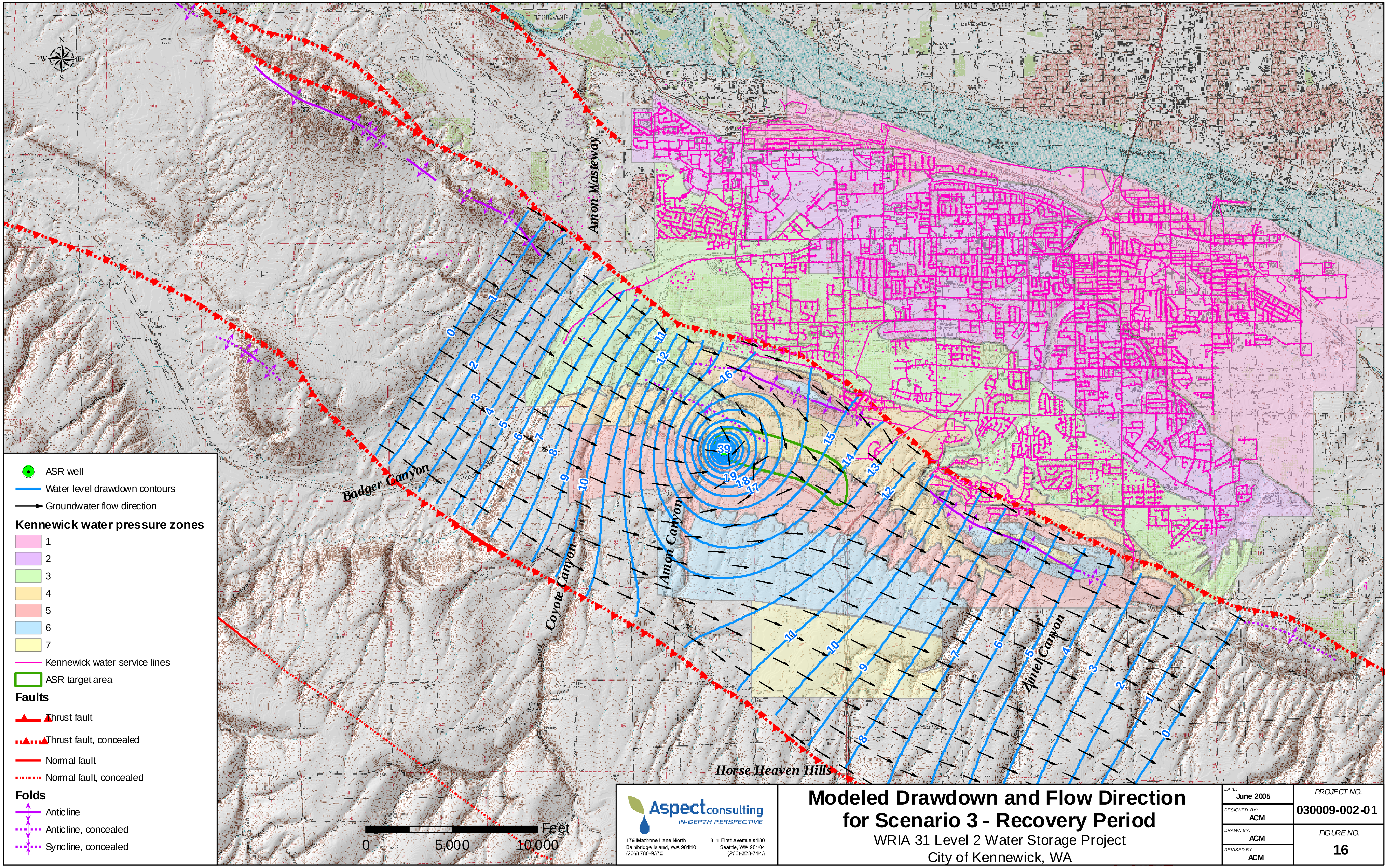
[illegible]

[illegible]
Seattle, WA [illegible]

# Modeled Mounding and Flow Direction for Scenario 3 - Recharge Period

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

| | |
|---|---|
| DATE: | June 2005 |
| DESIGNED BY: | ACM |
| DRAWN BY: | ACM |
| REVISED BY: | ACM |
| PROJECT NO. | 030009-002-01 |
| FIGURE NO. | 15 |



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## Modeled Drawdown and Flow Direction for Scenario 3 - Recovery Period

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City of Kennewick, WA

| | |
|---|---|
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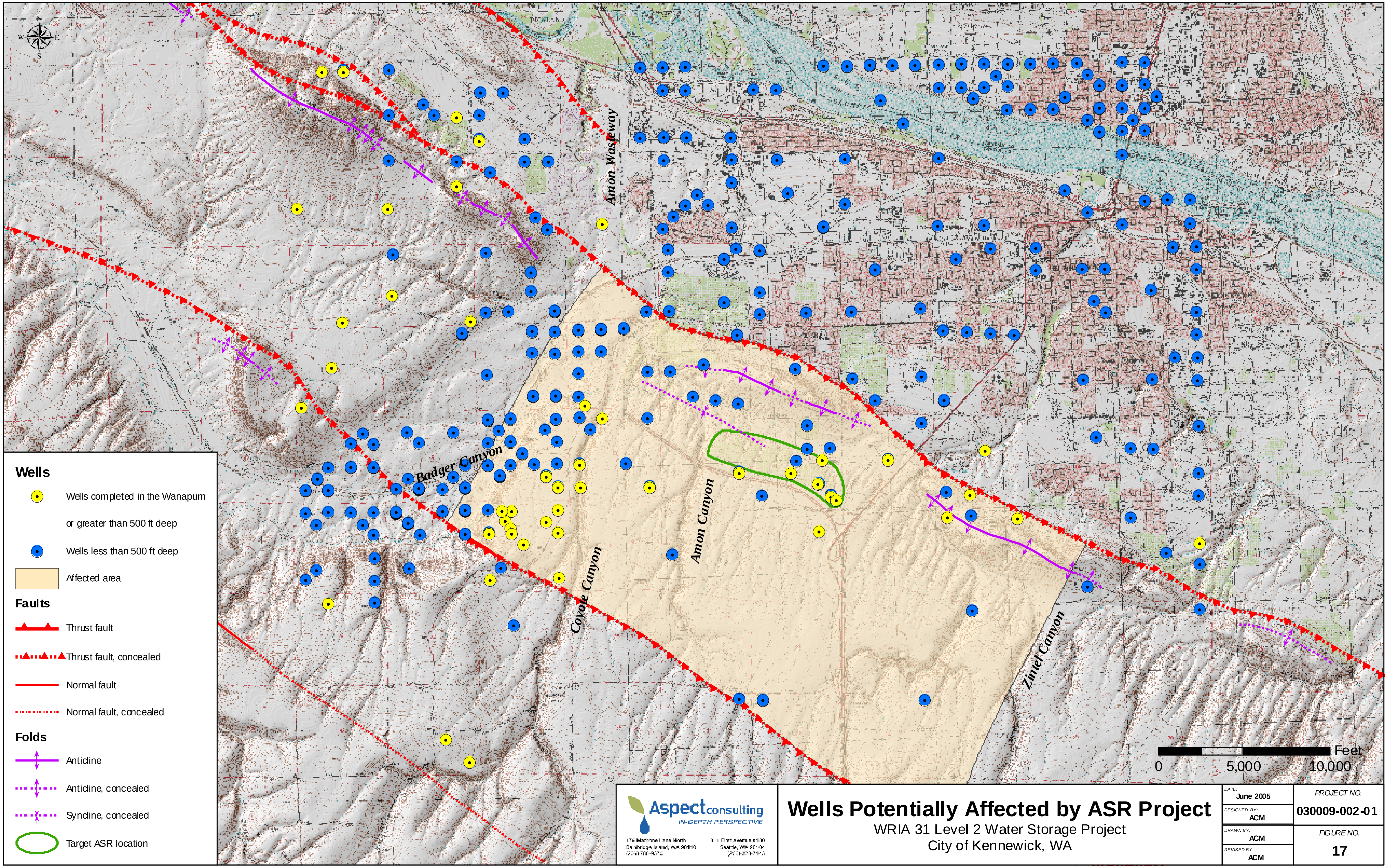
| REVISED BY: | ACM |

PROJECT NO.
030009-002-01

FIGURE NO.
16



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# Wells Potentially Affected by ASR Project

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City of Kennewick, WA

| | |
|---|---|
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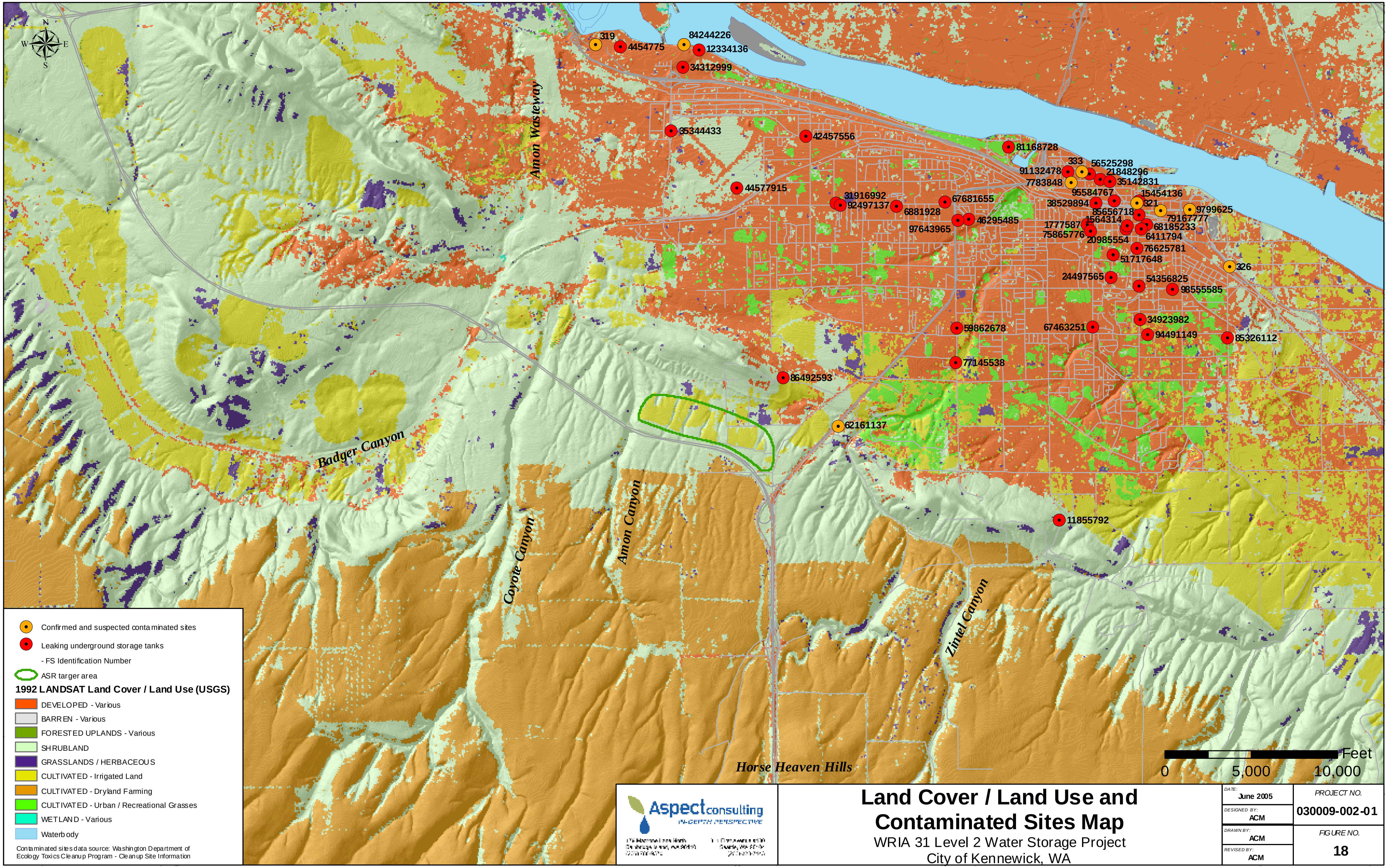
| DESIGNED BY: ACM | |
| DRAWN BY: ACM | FIGURE NO. 17 |
| REVISED BY: ACM | |



● Confirmed and suspected contaminated sites

● Leaking underground storage tanks

- FS Identification Number

○ ASR targer area

**1992 LANDSAT Land Cover / Land Use (USGS)**

| | |
|---|---|
| 🟧 | DEVELOPED - Various |
| ⬜ | BARREN - Various |
| 🟩 | FORESTED UPLANDS - Various |
| 🟩 | SHRUBLAND |
| 🟪 | GRASSLANDS / HERBACEOUS |
| 🟨 | CULTIVATED - Irrigated Land |
| 🟧 | CULTIVATED - Dryland Farming |
| 🟩 | CULTIVATED - Urban / Recreational Grasses |
| 🟦 | WETLAND - Various |
| 🟦 | Waterbody |

Contaminated sites data source: Washington Department of Ecology Toxics Cleanup Program - Cleanup Site Information

Aspect consulting
IN-DEPTH PERSPECTIVE

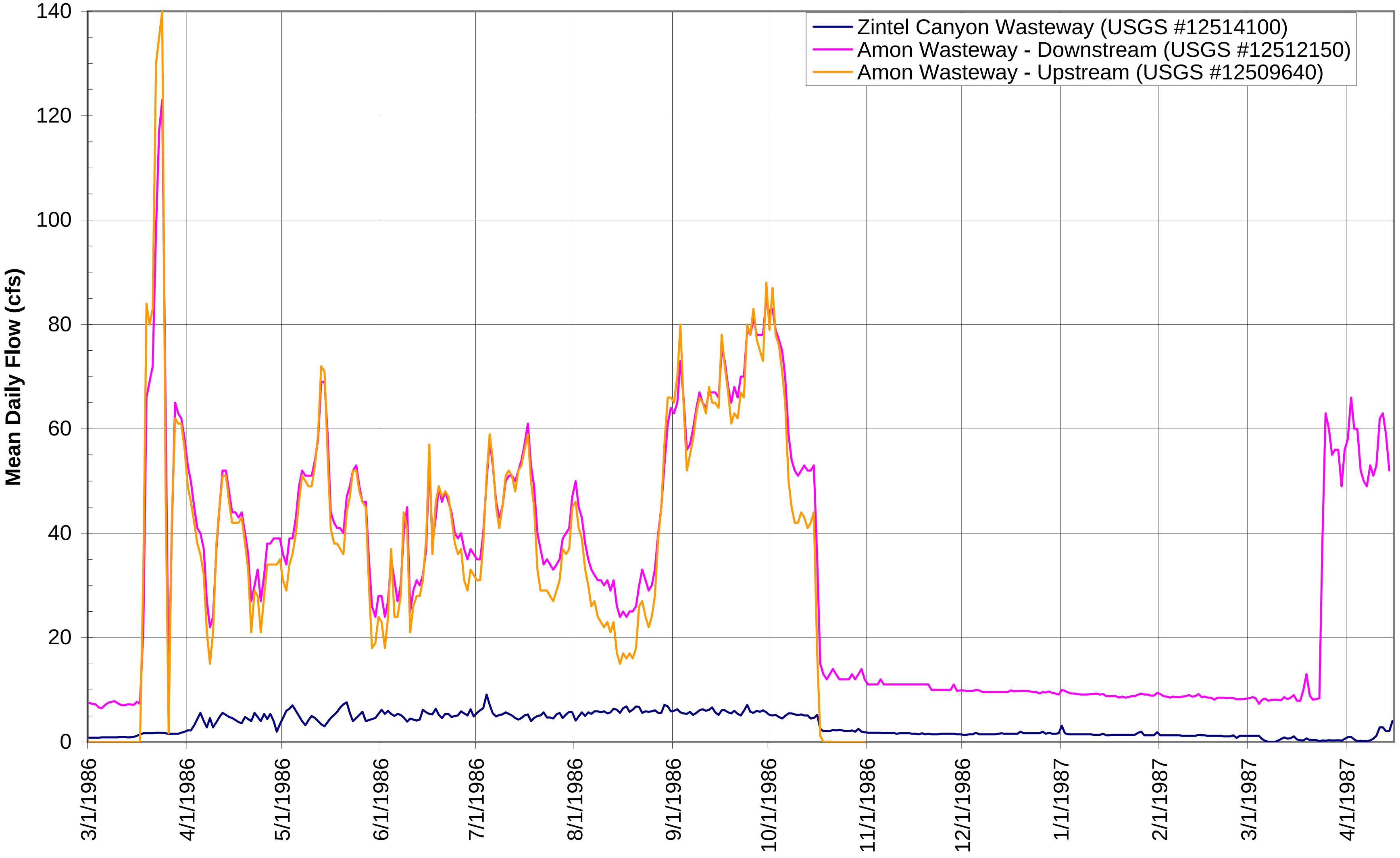
# Land Cover / Land Use and Contaminated Sites Map

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

| | |
|---|---|
| DATE: | June 2005 |
| DESIGNED BY: | ACM |
| DRAWN BY: | ACM |
| REVISED BY: | ACM |

PROJECT NO.
030009-002-01

FIGURE NO.
18



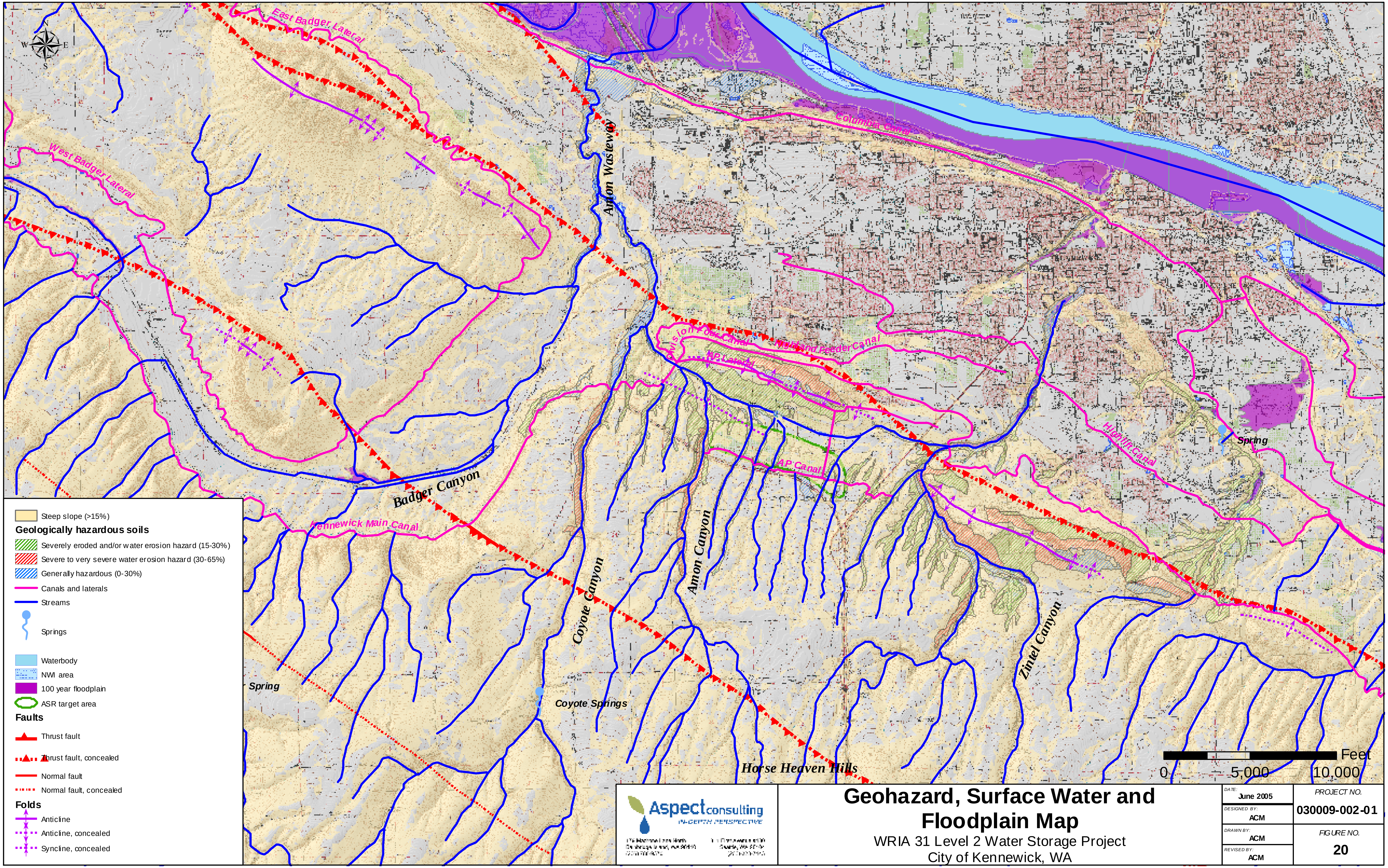
# Mean Daily Flows for Amon and Zintel Canyon Wasteways

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

**Figure 19**

Aspect consulting
IN-DEPTH PERSPECTIVE

V:\030009 WRIA 31\ASR Report\Streamflow_General.xls - Hydrographs



Aspect consulting
IN-DEPTH PERSPECTIVE

# Geohazard, Surface Water and Floodplain Map

WRIA 31 Level 2 Water Storage Project
City of Kennewick, WA

| | |
|---|---|
| DATE: June 2005 | PROJECT NO. 030009-002-01 |
| DESIGNED BY: ACM | |
| DRAWN BY: ACM | FIGURE NO. 20 |
| REVISED BY: ACM | |

# APPENDIX A

## Tables of Contaminated Sites and Leaking Underground Storage Tanks from Ecology

## Confirmed and Suspected Contaminated Sites Report Listed by Ecology

| FS_ID | COMMON_NM | LINE_1_AD | CITY_NM | ZIP_CD | ECOL_ STAT_CD | INDEP_ STATUS_CD | WARM_ BIN_NR | PRGM_ PLAN_CD | AFF_ MEDIA _CD | AFF_ MEDIA_ STAT _CD | BASE_ NEUTRAL_ CD | HALOG_ ORGANICS_CD | METALS_ PRIORITY_CD | METALS_OTHER_CD | PCB_ CD | PESTICIDES_ CD | PETRO_ PRODUCTS_ CD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 319 | Ben Franklin Transit Co | 1000 COLUMBIA PARK TRAIL | RICHLAND | 99352 | 4 | 1 | 3 | 4 | 1 | C | | | | | | | C |
| 319 | Ben Franklin Transit Co | 1000 COLUMBIA PARK TRAIL | RICHLAND | 99352 | 4 | 1 | 3 | 4 | 2 | S | | | | | | | S |
| 319 | Ben Franklin Transit Co | 1000 COLUMBIA PARK TRAIL | RICHLAND | 99352 | 4 | 1 | 3 | 4 | 4 | C | | | | | | | C |
| 321 | PUMP PAK & EATERY | 3 W COLUMBIA DR | KENNEWICK | 99336 | 3 | | 2 | | 1 | C | | | | | | | C |
| 321 | PUMP PAK & EATERY | 3 W COLUMBIA DR | KENNEWICK | 99336 | 3 | | 2 | | 4 | C | | | | | | | C |
| 326 | PACIFIC RECYCLING | 1615 CHEMICAL DR | KENNEWICK | 99336-5900 | 4 | 3 | 2 | 4 | 4 | C | | | | | | | C |
| 333 | KENNEWICK U HAUL | 800-812 W COLUMBIA DR | KENNEWICK | 99336 | 4 | 2 | 3 | 4 | 1 | C | | | | | C | | C |
| 333 | KENNEWICK U HAUL | 800-812 W COLUMBIA DR | KENNEWICK | 99336 | 4 | 2 | 3 | 4 | 4 | C | | C | | | C | | C |
| 7783848 | 428 N Hartford Drug Lab | 428 N HARTFORD | KENNEWICK | 99336 | 1 | | | | 4 | S | | | | | | | S |
| 9799625 | Consolidated Freightways Kennewick | 900 E BRUNEAU AVE | KENNEWICK | 99336 | 4 | | 5 | | 1 | C | | | | | | | C |
| 9799625 | Consolidated Freightways Kennewick | 900 E BRUNEAU AVE | KENNEWICK | 99336 | 4 | | 5 | | 4 | C | | | | | | | C |
| 62161137 | HB Painters Inc | 6147 W 36TH AVE | KENNEWICK | 99337 | 4 | | | 4 | 4 | C | | | | | | | C |
| 79167777 | TWIN CITY METALS | 455 E BRUNEAU | KENNEWICK | 99336 | 3 | | 1 | | 1 | S | | | S | | S | | S |
| 79167777 | TWIN CITY METALS | 455 E BRUNEAU | KENNEWICK | 99336 | 3 | | 1 | | 4 | C | | | C | | C | | C |
| 84244226 | COLUMBIA PARK MARINA | 1776 COLUMBIA DR SE | RICHLAND | 99352-4802 | 4 | 2 | | 4 | 1 | C | | | | | | | C |
| 84244226 | COLUMBIA PARK MARINA | 1776 COLUMBIA DR SE | RICHLAND | 99352-4802 | 4 | 2 | | 4 | 4 | C | | | | | | | C |

**Continued (same sites as above)**

| FS_ID | PHENOLS_ CD | NON_HALOG_ SOLV_CD | DIOXIN_ CD | PAH_ CD | REACTIVE_ WASTES_ CD | CORROSIVE_ WSTS_CD | RDIOACTV_ WASTES_CD | CONV_ ORGANICS_CD | CONV_ INORGANICS_CD | ASBESTOS_ CD | RESP_UNIT_ CD | ARSENIC_CD | MTBE_CD | UXO_CD | GIS_CALC_LAT_DECIMAL_NR | GIS_CALC_ LONG_DECIMAL_NR | Corrected_GIS_CALC_LONG_DECIMAL_NR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 319 | | | | | | | | C | | | CE | | | | 46.238 | 119.2405 | -119.2405 |
| 319 | | | | | | | | S | | | CE | | | | 46.238 | 119.2405 | -119.2405 |
| 319 | | | | | | | | C | | | CE | | | | 46.238 | 119.2405 | -119.2405 |
| 321 | | | | | | | | | | | CE | | | | 46.212 | 119.11711 | -119.11711 |
| 321 | | | | | | | | | | | CE | | | | 46.212 | 119.11711 | -119.11711 |
| 326 | | | | | | | | | | | CE | | | | 46.201 | 119.09602 | -119.09602 |
| 333 | | | | | | | | | | | CE | | | | 46.217 | 119.12939 | -119.12939 |
| 333 | | | | | | | | C | | | CE | | | | 46.217 | 119.12939 | -119.12939 |
| 7783848 | | S | | | S | S | | S | | | CE | | | | 46.215 | 119.1320686 | -119.1320686 |
| 9799625 | | | | | | | | | | | CE | | | | 46.211 | 119.10485 | -119.10485 |
| 9799625 | | | | | | | | | | | CE | | | | 46.211 | 119.10485 | -119.10485 |
| 62161137 | | | | | | | | | | | CE | | | | 46.177 | 119.18631 | -119.18631 |
| 79167777 | | | | | | | | | | | CE | | | | 46.211 | 119.11161 | -119.11161 |
| 79167777 | | S | | | | | | | | | CE | | | | 46.211 | 119.11161 | -119.11161 |
| 84244226 | | | | | | | | | | | CE | | | | 46.238 | 119.22009 | -119.22009 |
| 84244226 | | | | | | | | | | | CE | | | | 46.238 | 119.22009 | -119.22009 |

Refer to Confirmed & Suspected Contaminated Sites Report Record Layout for description of headers.

# CONFIRMED AND SUSPECTED CONTAMINATED SITES REPORT

## RECORD LAYOUT

**Please Note.** The Confirmed & Suspected Contaminated Sites data set contains the results of a join of several relational database tables. Basic site description information has been combined with affected media and contaminant types detail data. There may be the appearance of duplicate site entries. In other words, there may be only one or up to six records for each site--one record for each medium affected by contamination.

The data are subject to change at any time. Ecology does not guarantee the accuracy of the data and can not provide technical assistance in reading or manipulating the data. The Department of Ecology does not assume responsibility for any damage or potential damage caused by using this data on the requestor's computer.

| # | COLUMN NAME | DESCRIPTION | TYPE | LENGTH |
|---|---|---|---|---|
| 1 | COUNTY_NM | County Name | Text | 20 |
| 2 | COMMON_NM | Common Name (Site Name) | Text | 40 |
| 3 | LINE_1_AD | Line 1 Address (Site Location) | Text | 40 |
| 4 | CITY_NM | City Name | Text | 25 |
| 5 | ZIP_CD | Zip Code | Text | 10 |
| 6 | ECOL_STAT_CD | Ecology Status | Integer | 8 |
| 7 | INDEP_STAT | Independent Status | Integer | 8 |
| 8 | WARM_BIN_NR | WARM Bin Number | Text | 1 |
| 9 | PRGM_PLAN | Program Plan | Text | 1 |
| 10 | LAT_DEG_NR | Latitude, Degrees | Integer | 8 |

| | | | | |
|---|---|---|---|---|
| 11 | LAT_MIN_NR | Latitude, Minutes | Integer | 8 |
| 12 | LAT_SEC_NR | Latitude, Seconds | Float | |
| 13 | LONG_DEG_N | Longitude, Degrees | Integer | 8 |
| 14 | LONG_MIN_N | Longitude, Minutes | Integer | 8 |
| 15 | LONG_SEC_N | Longitude, Seconds | Float | |
| 16 | HORZ_COLL_ | Horizontal Collection Method Code | Integer | 8 |
| 17 | AFF_MEDIA_ | Affected Media Code | Text | 20 |
| 18 | BFF_MEDIA_ | Affected Media Status code | Text | 1 |
| 19 | BASE_NEUTR | Base/Neutral/Acid Organics Code | Text | 1 |
| 20 | HALOG_ORGA | Halogenated Organics Code | Text | 1 |
| 21 | METALS_PRI | Metals, Priority Pollutants Code | Text | 1 |
| 22 | METALS_OTH | Metals, Other Code | Text | 1 |
| 23 | PCB_CD | Polychlorinated bi_phenyls Code | Text | 1 |
| 24 | PESTICIDES | Pesticides Code | Text | 1 |
| 25 | PETRO_PROD | Petroleum Products Code | Text | 1 |

| | | | | |
|---|---|---|---|---|
| 26 | PHENOLS_CD | Phenolic Compounds Code | Text | 1 |
| 27 | NON_HALOG_ | Non-Halogenated Solvents Code | Text | 1 |
| 28 | DIOXIN_CD | Dioxins Code | Text | 1 |
| 29 | PAH_CD | Polynuclear Aromatic Hydrocarbons Code | Text | 1 |
| 30 | REACTIVE_W | Reactive Wastes Code | Text | 1 |
| 31 | CORROSIVE_ | Corrosive Wastes Code | Text | 1 |
| 32 | RDIOACTV_W | Radioactive Wastes Code | Text | 1 |
| 33 | CONV_ORGAN | Conventionals, Organic Code | Text | 1 |
| 34 | CONV_INORG | Conventionals, Inorganic Code | Text | 1 |
| 35 | ASBESTOS_C | Asbestos Code | Text | 1 |
| 36 | ARSENIC_CD | Arsenic Code | Text | 1 |
| 37 | MTBE_CD | Methyl Tertiary-Butyl Ether | Text | 1 |
| 38 | RESP_UNIT_ | Responsible Unit (TCP | Text | 10 |
| 39 | DBO_SITE_D | Site ID# (FS_ID) | Integer | 8 |

## CONFIRMED & SUSPECTED CONTAMINATED SITES REPORT

## DEFINITIONS

THIS REPORT IS SUBJECT TO REVISION. Within 90 days of learning of a potentially contaminated site, the Department of Ecology conducts an initial investigation of each site. If the initial investigation shows that further action is needed, the site will appear in the Confirmed & Suspected Contaminated Sites (CSCS) Report. Once remedial action has been completed, the Toxics Cleanup Program's management determines the removal of a site from the CSCS Report. The Hazardous Sites List is a subset of the CSCS Report. It contains those sites that have been ranked using the Washington Ranking Method.

PLEASE NOTE:

- Site owners and operators do not necessarily agree with Ecology's determination of site status.
- Ecology will update the site list database continually as new information becomes available.

REPORT ORGANIZATION. This data set is sorted by county. Within each county, the data are sorted by site name.

SITE STAT CODE = ECOLOGY SITE STATUS. Indicates the current status of sites relative to the MTCA cleanup process. Code choices are:

| | |
|---|---|
| *1* | *Awaiting Site Hazard Assessment (SHA)* |
| *2* | *Ranked, Awaiting Remedial Action (RA)* |
| *3* | *Remedial Action in progress* |
| *4* | *Independent Remedial Action* |
| *5* | *Construction Completed, Operation & Maintenance Underway* |
| *6* | *RA Completed, Confirmational Monitoring Underway* |
| *7* | *RA Conducted, residual contamination left on site; on-going institutional controls required* |
| *8* | *RA and all activities completed (no monitoring)* |

IND SITE STAT = INDEPENDENT SITE STATUS. This column only applies to those sites undergoing an independent cleanup. Code choices are:

| | |
|---|---|
| 1 | Release report received, awaiting assessment by PLP (PLP = Potentially Liable Person) |
| 2 | Independent Site Assessment or Interim RA Report received |
| 3 | Final Independent RA Report received |

WARM BIN#: Indicates the outcome of the WAshington Ranking Model (WARM). The WARM BIN Number will be a number between 1 and 5. A result of 1 indicates the greatest assessed risk to human health and to the environment. A result of 5 indicates the lowest assessed risk. A zero indicates that the site is either on the federal National Priorities List (NPL) or is a sub-site or operable unit of an NPL site. NPL sites are ranked under the federal Hazard Ranking System (HRS).

PROGRAM PLAN: As of September 1995, PROGRAM PLAN CODE consists of a look-up table with 4 valid code choices:

| | |
|---|---|
| 1 | Pre-Payment Site |
| 2 | Program Plan Site |
| 3 | IRAP Site |
| 4 | VCP Site |

LATITUDE/LONGITUDE DATA: Latitude and Longitude coordinates are included in this data set. (Because this information was obtained from a variety of sources, Ecology cannot guarantee its accuracy.)

HORIZONTAL COLLECTION METHOD CODE: The technique used to collect the latitude/longitude coordinates of a contaminated site. Codes currently in use are:

| | |
|---|---|
| 01 - 04 | Address Matching |
| 05 - 07 | Aerial Photography |
| 09 | Census Block 1990 Centroid |
| 12 | Digital or manual raw photo extraction |
| 13 - 14 | Digitized |
| 15 - 18 | GPS (Global Positioning Satellite) |
| 19 | Hand measured-paper map (map interpolation) |
| 28 | Zip Code Centroid |
| 29 | GPS (Code/Differential) |
| 99 | Unknown |

AFFECTED MEDIA: For each site, there may be contaminant information for up to six environmental media: Groundwater, surface water, air, soil, sediment or drinking water. Affected Media Codes are:

1 = Groundwater
2 = Surface Water
3 = Air
4 = Soil
5 = Sediments
6 = Drinking Water

AFFECTED MEDIA STATUS: The media status column and the numbered contaminant type columns may be coded:

C (Confirmed) - The presence of hazardous substances above MTCA cleanup levels has been confirmed by laboratory analysis (or by field determination in the case of petroleum contamination).

B (Below) - The presence of hazardous substances below MTCA cleanup levels has been confirmed by laboratory analysis (or field determination in the case of petroleum products). The B code may only be applied following completion of analytical work in conjunction with a Site Hazard Assessment (SHA) or Remedial Investigation/Feasibility Study (RI/FS).

S (Suspected) - Due to preliminary investigations and/or the nature of business operations or manufacturing processes, certain contaminants are suspected to be present at the site.

R (Remediated) - Contaminants have been treated, removed, or contained to meet cleanup levels established for the site. (This status determination may only be made by Ecology.)

CONTAMINANT GROUPS--DEFINITIONS AND EXAMPLES:

NUMBERS 1 THROUGH 17 CORRESPOND TO THE CONTAMINANT NUMBERS ON THE *Confirmed & Suspected Contaminated Sites* REPORT OR IN THE ELECTRONIC DATA SET.

1. Base/Neutral/Acid Organics: Hazardous substances typically included in the Base/Neutral/Acid fraction of EPA's priority pollutant compound list. Examples are: Acenaphthene; Hexachloro-benzene; Fluoranthene; 2,4-dinitro-toluene; Isophorone.

2. Halogenated Organic Compounds: Organic compounds, typically solvents, with one or more of the halogens (e.g., Chlorine, Bromine, Fluorine) incorporated into their structure. Examples are: Carbon Tetrachloride; Chloroform; Vinyl Acetate; 1,1,2,2-tetrachloroethane; freons.

3. EPA Priority Pollutants - Metals and Cyanide: Metals included in EPA's priority pollutant compounds list. Examples are: Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Cyanide, Lead, Mercury, Nickel, Selenium, Silver, Thallium and Zinc.

4. Metals - Other: Other non-priority pollutant metals. Examples are: Aluminum, Barium, Cobalt, Iron, Manganese and Tin.

5. Polychlorinated biPhenyls (PCBs): A specific "family" of aromatic chlorinated organic compounds, often referred to as "AROCLOR." Common types are: AROCLOR-1016, AROCLOR-1221, AROCLOR-1260.

6. Pesticides: Chemical agents used to control pests such as: fungicides, herbicides and insecticides. Examples are: Aldrin, Chlordane, Endrin, Diazinon, Folex, Malathion.

7. Petroleum Products: Crude oil and any fraction thereof. Each of these materials may consist of many specific chemical compounds. Examples are: Gasoline, diesel fuel, mineral oil.

8. Phenolic Compounds: Hazardous substances typically included in the acid extractable fraction of EPA's priority pollutant compound list. Examples are: 2,4,6-trichloro-phenol; Phenol; Cresols; Pentachlorophenol; Benzoic Acid.

9. Non-Halogenated Solvents: Organic solvents, typically volatile or semi-volatile, not containing any halogens. Examples are: Acrolein; Benzene; Toluene; Acetone; 4-Methyl-2-pentanone.

10. Dioxin: A family of more than 70 compounds of chlorinated dioxins. Examples: 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD); P-dioxin; Hexachlorodibenzo-p-dioxin; Polychlorinated dibenzo-para-dioxin (PCDD).

11. Polynuclear Aromatic Hydrocarbons (PAH): Hydrocarbons composed of two or more benzene rings. Examples are: Benzo-Fluoranthene; Chrysene; Anthracene; Acenapthene.

12. Reactive Wastes: Wastes that react violently upon contact with other substances (especially air or water) as defined by the Dangerous Waste Regulation (WAC 173-303-090(7)). They explode easily or are otherwise unstable. Examples: Peroxides; Metallic Sodium.

13. Corrosive Wastes: Wastes that are highly corrosive as defined by the Dangerous Waste Regulation (WAC 173-303-090(6)). Substances with very high (base) or very low (acid) pH. Examples: Nitric Acid, Sodium Hydroxide.

14. Radioactive Wastes: Wastes that emit more than background levels of radiation. Examples are: High and low level nuclear wastes; mixed nuclear wastes; Uranium mine tailings.

15. Conventional Contaminants, Organic: Unspecified organic matter that imposes an oxygen demand during its decomposition. This is reflected by elevated Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and/or Total Organic Carbon (TOC). Typically a component of municipal solid waste leachates, sewage, septage, food wastes, wood waste leachate and similar organic wastes.

16. Conventional Contaminants, Inorganic: Non-metallic inorganic substances or indicator parameters that may indicate the existence of contamination if present at unusual levels. Examples are: Chloride, Sulfur compounds, Nitrogen compounds, pH, conductivity, hardness and alkalinity.

17. Asbestos: All forms of Asbestos. Asbestos fibers have been used in products such as building materials, friction products, and heat-resistant materials.

18. Arsenic: A toxic heavy metal that may be absorbed via ingestion, inhalation, or by permeating skin or mucous membranes. Arsenic was added to this report (May, 2001 edition) due to increasing concern over area-wide arsenic contamination problems in certain areas of the state.

19. Methyl tertiary-butyl ether (MTBE): MTBE is a volatile oxygen-containing organic compound that was formerly used as a gasoline additive to promote complete combustion and help reduce air pollution. MTBE is now being detected in groundwater throughout the United States. Its use in fuel has been banned because it persists in the environment, moves rapidly through soil and groundwater, and is a possible carcinogen.

RESPONSIBLE UNIT CODE:

| | |
|---|---|
| CE | Central Region |
| EA | Eastern Region |
| EP | EPA |
| HA | Hanford (Nuclear Waste Program) |
| HQ | Headquarters Site Cleanup Section |
| IN | Industrial Section |
| NW | Northwest Region |
| SW | Southwest Region |
| RC | RCRA (Hazardous Waste Program) |

# Leaking Underground Storage Tanks Listed by Ecology

| FS_ID | City | Site_ID | Release ID | Site Name | Alternate Name | Address | Zipcode | Release Notification Date | Release Status Change Date | Comment | Media Comment | GIS Calculated Latitude | GIS Calculated Longitude |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 319 | Richland | 97442 | 1078 | BENTON-FRNKLN PBLC TRNSP BNFT AREA ATHTY | BEN FRANKLIN TRANSIT | 1000 COLUMBIA DR SE | 993524764 | 6/1/1990 | 9/19/1996 | Monitoring | Ground Water | 46.23841 | 119.2405 |
| 319 | Richland | 97442 | 1078 | BENTON-FRNKLN PBLC TRNSP BNFT AREA ATHTY | BEN FRANKLIN TRANSIT | 1000 COLUMBIA DR SE | 993524764 | 6/1/1990 | 9/19/1996 | Monitoring | Soil | 46.23841 | 119.2405 |
| 319 | Richland | 97442 | 484124 | BENTON-FRNKLN PBLC TRNSP BNFT AREA ATHTY | BENTON-FRNKLN PBLC TRNSP BNFT AREA ATHTY | 1000 COLUMBIA DR SE | 993524764 | 12/8/1998 | 12/2/1998 | Cleanup Started | Ground Water | 46.23841 | 119.2405 |
| 319 | Richland | 97442 | 484124 | BENTON-FRNKLN PBLC TRNSP BNFT AREA ATHTY | BENTON-FRNKLN PBLC TRNSP BNFT AREA ATHTY | 1000 COLUMBIA DR SE | 993524764 | 12/8/1998 | 12/2/1998 | Cleanup Started | Soil | 46.23841 | 119.2405 |
| 321 | Kennewick | 200001 | 3454 | PUMP PAK & EATERY |  | 3 W COLUMBIA DR | 99336 | 11/1/1989 | 1/4/1990 | Cleanup Started | Ground Water | 46.21191 | 119.11711 |
| 321 | Kennewick | 200001 | 3454 | PUMP PAK & EATERY |  | 3 W COLUMBIA DR | 99336 | 11/1/1989 | 1/4/1990 | Cleanup Started | Soil | 46.21191 | 119.11711 |
| 333 | Kennewick | 7226 | 4813 | U-HAUL CENTER OF KENNEWICK |  | 800 W. COLUMBIA DR | 993363543 | 9/28/1992 | 9/11/1992 | Cleanup Started | Ground Water | 46.21691 | 119.12939 |
| 333 | Kennewick | 7226 | 4813 | U-HAUL CENTER OF KENNEWICK |  | 800 W. COLUMBIA DR | 993363543 | 9/28/1992 | 9/11/1992 | Cleanup Started | Soil | 46.21691 | 119.12939 |
| 1564314 | Kennewick | 12347 | 375299 | KENNEWICK MAIN CTRL OFC BLDG (4320-B01 |  | 15 S BENTON ST | 993363802 | 10/11/1989 | 8/6/1996 | Cleanup Started | Soil | 46.20828 | 119.11943 |
| 1564314 | Kennewick | 12347 | 375299 | KENNEWICK MAIN CTRL OFC BLDG (4320-B01 |  | 15 S BENTON ST | 993363802 | 10/11/1989 | 3/3/2004 | Reported Cleaned Up | Soil | 46.20828 | 119.11943 |
| 1777587 | Kennewick | 7788 | 365425 | KENNEWICK SECTION TOOL HOUSE | UNION PACIFIC RAILROAD KENNEWICK SECTION | NW1/4 SECTION 6 T8N R30E | 99336 | 9/6/1990 | 9/6/1990 | Cleanup Started | Soil | 46.208551 | 119.1284 |
| 1777587 | Kennewick | 7788 | 365425 | KENNEWICK SECTION TOOL HOUSE | UNION PACIFIC RAILROAD KENNEWICK SECTION | NW1/4 SECTION 6 T8N R30E | 99336 | 9/6/1990 | 8/7/1991 | Reported Cleaned Up | Soil | 46.208551 | 119.1284 |
| 4454775 | Richland | 12664 | 3329 | RECO INC | SEAFIRST TRUST FUND SITE | 1232 COLUMBIA DRIVE SE | 993524762 | 11/2/1989 | 9/21/1990 | Cleanup Started | Ground Water | 46.23801 | 119.23477 |
| 4454775 | Richland | 12664 | 3329 | RECO INC | SEAFIRST TRUST FUND SITE | 1232 COLUMBIA DRIVE SE | 993524762 | 11/2/1989 | 9/21/1990 | Cleanup Started | Soil | 46.23801 | 119.23477 |
| 6411794 | Kennewick | 101623 | 4867 | BEAR MART AUTO SALES |  | 1 EAST FIRST AVE | 99336 | 8/3/1992 | 8/3/1992 | Awaiting Cleanup | Soil | 46.20779 | 119.11605 |
| 6411794 | Kennewick | 101623 | 4867 | BEAR MART AUTO SALES |  | 1 EAST FIRST AVE | 99336 | 8/3/1992 | 3/31/2004 | Reported Cleaned Up | Soil | 46.20779 | 119.11605 |
| 6881928 | Kennewick | 3665 | 414559 | B-OK |  | 3809 W CLEARWATER | 99336 | 3/7/1997 | 3/5/1997 | Cleanup Started | Soil | 46.21207 | 119.17205 |
| 6881928 | Kennewick | 3665 | 414559 | B-OK |  | 3809 W CLEARWATER | 99336 | 3/7/1997 | 4/29/1997 | Reported Cleaned Up | Soil | 46.21207 | 119.17205 |
| 9799625 | Kennewick | 11011 | 441765 | CONSOLIDATED FREIGHTWAYS |  | 900 E BRUNEAU AVE | 993363723 | 4/3/1998 | 3/6/1998 | Cleanup Started | Soil | 46.21074 | 119.10485 |
| 9799625 | Kennewick | 11011 | 441765 | CONSOLIDATED FREIGHTWAYS |  | 900 E BRUNEAU AVE | 993363723 | 4/3/1998 | 4/3/1998 | Awaiting Cleanup | Soil | 46.21074 | 119.10485 |
| 9799625 | Kennewick | 11011 | 441765 | CONSOLIDATED FREIGHTWAYS |  | 900 E BRUNEAU AVE | 993363723 | 4/3/1998 | 3/14/2001 | Monitoring | Soil | 46.21074 | 119.10485 |
| 11855792 | Kennewick | 11007 | 4845 | CITY OF KENNEWICK-MILLION GALLON RESVR | KENNEWICK PUMP STATION | 54TH & OLYMPIA | 99336 | 4/1/1993 | 4/1/1993 | Cleanup Started | Soil | 46.16167 | 119.13602 |
| 11855792 | Kennewick | 11007 | 4845 | CITY OF KENNEWICK-MILLION GALLON RESVR | KENNEWICK PUMP STATION | 54TH & OLYMPIA | 99336 | 4/1/1993 | 7/27/1993 | Reported Cleaned Up | Soil | 46.16167 | 119.13602 |
| 12334136 | Kennewick | 9265 | 4848 | COLUMBIA PARK | COLUMBIA PARK SHOP | 5111 SE COLUMBIA DRIVE | 993524819 | 7/27/1993 | 7/22/1993 | Reported Cleaned Up | Soil | 46.23741 | 119.2167 |
| 12334136 | Kennewick | 9265 | 4848 | COLUMBIA PARK | COLUMBIA PARK SHOP | 5111 SE COLUMBIA DRIVE | 993524819 | 7/27/1993 | 7/27/1993 | Cleanup Started | Soil | 46.23741 | 119.2167 |
| 15454136 | Kennewick | 4644 | 485698 | PETROLEUM PUMP COMPANY |  | 23 W COLUMBIA DR | 993363659 | 3/18/1992 | 3/6/1972 | Cleanup Started | Soil | 46.21216 | 119.11644 |
| 15454136 | Kennewick | 4644 | 485698 | PETROLEUM PUMP COMPANY |  | 23 W COLUMBIA DR | 993363659 | 3/18/1992 | 4/27/2000 | Reported Cleaned Up | Soil | 46.21216 | 119.11644 |
| 20985554 | Kennewick | 2111 | 4883 | BURKS BROS CONOCO |  | 124 W 1ST AVE | 993363931 | 10/14/1992 | 10/8/1992 | Cleanup Started | Soil | 46.2078 | 119.11966 |
| 20985554 | Kennewick | 2111 | 4883 | BURKS BROS CONOCO |  | 124 W 1ST AVE | 993363931 | 10/14/1992 | 1/25/2000 | Reported Cleaned Up | Soil | 46.2078 | 119.11966 |
| 21848296 | Kennewick | 4115 | 591718 | PIK-A-POP #8 | TIME OIL CO PROPERTY 01-052 | 526 W COLUMBIA DR | 993363650 | 7/22/1994 | 7/22/1994 | Cleanup Started | Soil | 46.21566691 | 119.1252622 |
| 21848296 | Kennewick | 4115 | 591718 | PIK-A-POP #8 | TIME OIL CO PROPERTY 01-052 | 526 W COLUMBIA DR | 993363650 | 7/22/1994 | 7/22/2003 | Reported Cleaned Up | Soil | 46.21566691 | 119.1252622 |
| 24497565 | Kennewick | 2968 | 4873 | KENNEWICK SCHOOL DIST BUS GARAGE | KENNEWICK SCHOOL DIST #17 BUS LOT | 8TH & DAYTON ST | 99336 | 8/27/1992 | 8/27/1992 | Cleanup Started | Soil | 46.20012 | 119.12318 |
| 24497565 | Kennewick | 2968 | 4873 | KENNEWICK SCHOOL DIST BUS GARAGE | KENNEWICK SCHOOL DIST #17 BUS LOT | 8TH & DAYTON ST | 99336 | 8/27/1992 | 6/1/1995 | Reported Cleaned Up | Soil | 46.20012 | 119.12318 |
| 24497565 | Kennewick | 2968 | 368658 | KENNEWICK SCHOOL DIST BUS GARAGE | KENNEWICK SCHOOL DIST #17 BUS GARAGE | 8TH & DAYTON ST | 99336 | 4/2/1990 | 4/2/1990 | Cleanup Started | Soil | 46.20012 | 119.12318 |
| 24497565 | Kennewick | 2968 | 368658 | KENNEWICK SCHOOL DIST BUS GARAGE | KENNEWICK SCHOOL DIST #17 BUS GARAGE | 8TH & DAYTON ST | 99336 | 4/2/1990 | 8/3/1992 | Reported Cleaned Up | Soil | 46.20012 | 119.12318 |
| 24497565 | Kennewick | 2968 | 368678 | KENNEWICK SCHOOL DIST BUS GARAGE | KENNEWICK SCHOOL DIST #17 BUS GARAGE | 8TH & DAYTON ST | 99336 | 1/19/1993 | 6/14/1996 | Awaiting Cleanup | Soil | 46.20012 | 119.12318 |
| 24497565 | Kennewick | 2968 | 368678 | KENNEWICK SCHOOL DIST BUS GARAGE | KENNEWICK SCHOOL DIST #17 BUS GARAGE | 8TH & DAYTON ST | 99336 | 1/19/1993 | 3/23/2004 | Reported Cleaned Up | Soil | 46.20012 | 119.12318 |
| 31916992 | Kennewick | 12375 | 402358 | HIGHLANDS GARAGE (4865-B02) | GTE/HIGHLANDS GARAGE | 4916 W CLEARWATER | 993361912 | 3/10/1994 | 7/6/1993 | Cleanup Started | Soil | 46.21263 | 119.18581 |
| 34312999 | Richland | 1891 | 3403 | LORNE BANGERT FORD-DODGE | LORNE BANGERT FORD | 1775 FOWLER | 993524807 | 12/6/1991 | 12/6/1991 | Cleanup Started | Soil | 46.23469 | 119.22046 |
| 34312999 | Richland | 1891 | 3403 | LORNE BANGERT FORD-DODGE | LORNE BANGERT FORD | 1775 FOWLER | 993524807 | 12/6/1991 | 12/19/1991 | Reported Cleaned Up | Soil | 46.23469 | 119.22046 |
| 34923982 | Kennewick | 3449 | 3399 | WASTE MANAGEMENT OF KENNEWICK |  | 1611 S WASHINGTON ST | 99337 | 10/18/1991 | 10/18/1991 | Cleanup Started | Ground Water | 46.19326 | 119.11676 |
| 34923982 | Kennewick | 3449 | 3399 | WASTE MANAGEMENT OF KENNEWICK |  | 1611 S WASHINGTON ST | 99337 | 10/18/1991 | 10/18/1991 | Cleanup Started | Soil | 46.19326 | 119.11676 |
| 34923982 | Kennewick | 3449 | 3399 | WASTE MANAGEMENT OF KENNEWICK |  | 1611 S WASHINGTON ST | 99337 | 10/18/1991 | 12/27/1993 | Reported Cleaned Up | Ground Water | 46.19326 | 119.11676 |
| 34923982 | Kennewick | 3449 | 3399 | WASTE MANAGEMENT OF KENNEWICK |  | 1611 S WASHINGTON ST | 99337 | 10/18/1991 | 12/27/1993 | Reported Cleaned Up | Soil | 46.19326 | 119.11676 |
| 35142831 | Kennewick | 6695 | 471478 | MIDNITE MARINE |  | 420 W COLUMBIA DRIVE | 993363652 | 7/13/1988 | 5/3/1988 | Cleanup Started | Ground Water | 46.21528 | 119.12322 |
| 35142831 | Kennewick | 6695 | 471478 | MIDNITE MARINE |  | 420 W COLUMBIA DRIVE | 993363652 | 7/13/1988 | 5/3/1988 | Cleanup Started | Soil | 46.21528 | 119.12322 |
| 35142831 | Kennewick | 6695 | 471478 | MIDNITE MARINE |  | 420 W COLUMBIA DRIVE | 993363652 | 7/13/1988 | 3/22/2004 | Reported Cleaned Up | Ground Water | 46.21528 | 119.12322 |
| 35142831 | Kennewick | 6695 | 471478 | MIDNITE MARINE |  | 420 W COLUMBIA DRIVE | 993363652 | 7/13/1988 | 3/22/2004 | Reported Cleaned Up | Soil | 46.21528 | 119.12322 |
| 35344433 | Richland | 7750 | 1056 | GULL INDUSTRIES, INC. #1625 | GULL SERVICE STATION | 1300 COLUMBIA CENTER BLVD | 99352 | 2/2/1990 | 1/30/1990 | Cleanup Started | Ground Water | 46.22455 | 119.22331 |
| 35344433 | Richland | 7750 | 1056 | GULL INDUSTRIES, INC. #1625 | GULL SERVICE STATION | 1300 COLUMBIA CENTER BLVD | 99352 | 2/2/1990 | 1/30/1990 | Cleanup Started | Soil | 46.22455 | 119.22331 |
| 35344433 | Richland | 7750 | 1056 | GULL INDUSTRIES, INC. #1625 | GULL SERVICE STATION | 1300 COLUMBIA CENTER BLVD | 99352 | 2/2/1990 | 1/22/1991 | Monitoring | Ground Water | 46.22455 | 119.22331 |
| 35344433 | Richland | 7750 | 1056 | GULL INDUSTRIES, INC. #1625 | GULL SERVICE STATION | 1300 COLUMBIA CENTER BLVD | 99352 | 2/2/1990 | 1/22/1991 | Monitoring | Soil | 46.22455 | 119.22331 |
| 35344433 | Richland | 7750 | 1056 | GULL INDUSTRIES, INC. #1625 | GULL SERVICE STATION | 1300 COLUMBIA CENTER BLVD | 99352 | 2/2/1990 | 4/27/2000 | Reported Cleaned Up | Ground Water | 46.22455 | 119.22331 |
| 35344433 | Richland | 7750 | 1056 | GULL INDUSTRIES, INC. #1625 | GULL SERVICE STATION | 1300 COLUMBIA CENTER BLVD | 99352 | 2/2/1990 | 4/27/2000 | Reported Cleaned Up | Soil | 46.22455 | 119.22331 |
| 38529894 | Kennewick | 100425 | 3373 | DAIRYGOLD | BNRR/DAIRYGOLD | 229 N FRUITLAND | 993363615 | 4/2/1991 | 6/5/1996 | Awaiting Cleanup | Soil | 46.212 | 119.1264 |
| 42457556 | Kennewick | 101090 | 4893 | SMITTY'S CONOCO #270 |  | 5304 W CANAL DR | 99336 | 12/2/1993 | 12/2/1993 | Cleanup Started | Soil | 46.2234 | 119.19256 |
| 42457556 | Kennewick | 101090 | 4893 | SMITTY'S CONOCO #270 |  | 5304 W CANAL DR | 99336 | 12/2/1993 | 6/28/1996 | Reported Cleaned Up | Soil | 46.2234 | 119.19256 |
| 44577915 | Kennewick | 573 | 4807 | KENNEWICK BISHOPS STOREHOUSE | LDS CHURCH BISHOPS STOREHOUSE | 6500 W DESCHUTES | 993367718 | 7/16/1993 | 7/16/1993 | Cleanup Started | Soil | 46.21538 | 119.20847 |
| 44577915 | Kennewick | 573 | 4807 | KENNEWICK BISHOPS STOREHOUSE | LDS CHURCH BISHOPS STOREHOUSE | 6500 W DESCHUTES | 993367718 | 7/16/1993 | 7/16/1993 | Reported Cleaned Up | Soil | 46.21538 | 119.20847 |
| 46295485 | Kennewick | 5203 | 404219 | KENNEWICK AVENUE CHEVRON |  | 2610 W KENNEWICK AVE | 993360000 | 11/7/1994 | 11/7/1994 | Cleanup Started | Soil | 46.20971 | 119.15564 |
| 46295485 | Kennewick | 5203 | 404219 | KENNEWICK AVENUE CHEVRON |  | 2610 W KENNEWICK AVE | 993360000 | 11/7/1994 | 4/27/2000 | Reported Cleaned Up | Soil | 46.20971 | 119.15564 |
| 51717648 | Kennewick | 11004 | 404462 | FIRE STATION #1 |  | 600 S DAYTON | 99336 | 1/22/1994 | 12/2/1993 | Cleanup Started | Soil | 46.20364 | 119.12268 |
| 51717648 | Kennewick | 11004 | 404462 | FIRE STATION #1 |  | 600 S DAYTON | 99336 | 1/22/1994 | 12/3/1993 | Reported Cleaned Up | Soil | 46.20364 | 119.12268 |
| 54356825 | Kennewick | 5055 | 3393 | CHEVRON 90450 | CHEVRON 60090450 | 911 S WASHINGTON ST | 993365604 | 9/16/1991 | 4/20/1992 | Cleanup Started | Ground Water | 46.19858 | 119.11689 |
| 54356825 | Kennewick | 5055 | 3393 | CHEVRON 90450 | CHEVRON 60090450 | 911 S WASHINGTON ST | 993365604 | 9/16/1991 | 4/27/2000 | Reported Cleaned Up | Ground Water | 46.19858 | 119.11689 |
| 56525298 | Kennewick | 12649 | 425137 | B & B MOTORS |  | 719 COLUMBIA DRIVE | 99336 | 6/5/1997 | 2/10/1997 | Cleanup Started | Soil | 46.21664 | 119.12777 |
| 56525298 | Kennewick | 12649 | 425137 | B & B MOTORS |  | 719 COLUMBIA DRIVE | 99336 | 6/5/1997 | 4/27/2000 | Reported Cleaned Up | Soil | 46.21664 | 119.12777 |
| 59862678 | Kennewick | 3682 | 1042 | BENTON COUNTY ROAD DEPT AREA 2 YARD | BENTON COUNTY ROAD DEPT | 1709 S ELY | 993372836 | 11/8/1989 | 11/8/1989 | Cleanup Started | Soil | 46.19239 | 119.15884 |
| 59862678 | Kennewick | 3682 | 1042 | BENTON COUNTY ROAD DEPT AREA 2 YARD | BENTON COUNTY ROAD DEPT | 1709 S ELY | 993372836 | 11/8/1989 | 6/1/1995 | Reported Cleaned Up | Soil | 46.19239 | 119.15884 |
| 67463251 | Kennewick | 4239 | 414717 | A. G. EDWARDS, INC. |  | T8N R28E SEC.26 | 99336 | 5/19/1997 | 5/19/1997 | Awaiting Cleanup | Soil | 46.192328 | 119.127566 |
| 67463251 | Kennewick | 4239 | 414717 | A. G. EDWARDS, INC. |  | T8N R28E SEC.26 | 99336 | 5/19/1997 | 4/27/2000 | Reported Cleaned Up | Soil | 46.192328 | 119.127566 |
| 67681655 | Kennewick | 175 | 4882 | SANDVIG OLDSMOBILE |  | 2920 W CLEARWATER AVE | 993360625 | 10/15/1992 | 10/15/1992 | Cleanup Started | Soil | 46.21251 | 119.16109 |

# Leaking Underground Storage Tanks Listed by Ecology

| FS_ID | City | Site_ID | Release ID | Site Name | Alternate Name | Address | Zipcode | Release Notification Date | Release Status Change Date | Comment | Media Comment | GIS Calculated Latitude | GIS Calculated Longitude |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 67681655 | Kennewick | 175 | 4882 | SANDVIG OLDSMOBILE | | 2920 W CLEARWATER AVE | 993360625 | 10/15/1992 | 11/16/1992 | Reported Cleaned Up | Soil | 46.21251 | 119.16109 |
| 68185233 | Kennewick | 101088 | 4839 | LUDWIG OIL COMPANY | | 108 E KENNEWICK AVENUE | 993363755 | 9/25/1993 | 9/23/1993 | Reported Cleaned Up | Soil | 46.2084 | 119.1148 |
| 68185233 | Kennewick | 101088 | 4839 | LUDWIG OIL COMPANY | | 108 E KENNEWICK AVENUE | 993363755 | 9/25/1993 | 9/25/1993 | Cleanup Started | Soil | 46.2084 | 119.1148 |
| 75865776 | Kennewick | 100444 | 443885 | SMITTY'S CONOCO #240 | | 33 S GARFIELD | 993265548 | 2/25/1991 | 2/25/1991 | Awaiting Cleanup | Soil | 46.20754 | 119.12773 |
| 76625781 | Kennewick | 443904 | 443909 | USA AUTOBODY | | 320 S WASHINGTON ST | 99335 | 7/12/1995 | 5/12/1995 | Cleanup Started | Soil | 46.20461 | 119.11724 |
| 76625781 | Kennewick | 443904 | 443909 | USA AUTOBODY | | 320 S WASHINGTON ST | 99335 | 7/12/1995 | 7/12/1995 | Reported Cleaned Up | Soil | 46.20461 | 119.11724 |
| 77145538 | Kennewick | 1837 | 441596 | CONTRACTORS EQUIPMENT MAINTENANCE INC. | | 2312 S ELY PO BOX 7117 | 993360614 | 2/22/1991 | 2/22/1991 | Cleanup Started | Soil | 46.18702 | 119.15923 |
| 77145538 | Kennewick | 1837 | 441596 | CONTRACTORS EQUIPMENT MAINTENANCE INC. | | 2312 S ELY PO BOX 7117 | 993360614 | 2/22/1991 | 5/6/1991 | Reported Cleaned Up | Soil | 46.18702 | 119.15923 |
| 81168728 | Kennewick | 12020 | 4827 | COLUMBIA PARK GOLF COURSE | | COLUMBIA DRIVE | 99352 | 3/23/1993 | 3/23/1993 | Cleanup Started | Soil | 46.22116 | 119.14623 |
| 81168728 | Kennewick | 12020 | 4827 | COLUMBIA PARK GOLF COURSE | | COLUMBIA DRIVE | 99352 | 3/23/1993 | 7/27/1993 | Reported Cleaned Up | Soil | 46.22116 | 119.14623 |
| 84244226 | Richland | 9266 | 404410 | THE BOAT SHOP MARINA, INC | | 1776 COLUMBIA DR SE | 993524802 | 6/29/1994 | 6/27/1994 | Cleanup Started | Ground Water | 46.2382 | 119.22009 |
| 84244226 | Richland | 9266 | 404410 | THE BOAT SHOP MARINA, INC | | 1776 COLUMBIA DR SE | 993524802 | 6/29/1994 | 6/27/1994 | Cleanup Started | Soil | 46.2382 | 119.22009 |
| 84244226 | Richland | 9266 | 404410 | THE BOAT SHOP MARINA, INC | | 1776 COLUMBIA DR SE | 993524802 | 6/29/1994 | 2/17/2000 | Reported Cleaned Up | Ground Water | 46.2382 | 119.22009 |
| 84244226 | Richland | 9266 | 404410 | THE BOAT SHOP MARINA, INC | | 1776 COLUMBIA DR SE | 993524802 | 6/29/1994 | 2/17/2000 | Reported Cleaned Up | Soil | 46.2382 | 119.22009 |
| 85326112 | Kennewick | 101563 | 3418 | DON HIGHTOWER | NAVAJO TRUCKING | 1908 S OAK ST | 99337 | 2/3/1992 | 2/3/1992 | Cleanup Started | Soil | 46.19015 | 119.09684 |
| 85326112 | Kennewick | 101563 | 3418 | DON HIGHTOWER | NAVAJO TRUCKING | 1908 S OAK ST | 99337 | 2/3/1992 | 2/26/1992 | Reported Cleaned Up | Soil | 46.19015 | 119.09684 |
| 85656718 | Kennewick | 6123 | 404326 | SECO CONST EQUIP INC | | 110 NO WASHINGTON | 993363735 | 2/8/1994 | 2/8/1994 | Cleanup Started | Soil | 46.20991 | 119.11656 |
| 85656718 | Kennewick | 6123 | 404326 | SECO CONST EQUIP INC | | 110 NO WASHINGTON | 993363735 | 2/8/1994 | 3/25/1994 | Reported Cleaned Up | Soil | 46.20991 | 119.11656 |
| 86492593 | Kennewick | 11008 | 4846 | CITY OF KENNEWICK-MILLION GAL. RESERVO | CITY OF KENNEWICK PUMP STATION | 26TH & IRVING | 99336 | 4/1/1993 | 4/1/1993 | Cleanup Started | Soil | 46.18505 | 119.19864 |
| 86492593 | Kennewick | 11008 | 4846 | CITY OF KENNEWICK-MILLION GAL. RESERVO | CITY OF KENNEWICK PUMP STATION | 26TH & IRVING | 99336 | 4/1/1993 | 7/27/1993 | Reported Cleaned Up | Soil | 46.18505 | 119.19864 |
| 91132478 | Kennewick | 508319 | 530469 | OVERTURF VOLKSWAGON AUDI | | 1016 W COLUMBIA DR | 99336 | 3/15/2000 | 3/3/1997 | Cleanup Started | Soil | 46.21705 | 119.13275 |
| 91132478 | Kennewick | 508319 | 530469 | OVERTURF VOLKSWAGON AUDI | | 1016 W COLUMBIA DR | 99336 | 3/15/2000 | 3/15/2000 | Reported Cleaned Up | Soil | 46.21705 | 119.13275 |
| 92497137 | Kennewick | 100576 | 493357 | TRUAX BP #58 | | 4819 W CLEARWATER AVE | 99336 | 10/1/1994 | 7/13/1994 | Awaiting Cleanup | Soil | 46.21224 | 119.18495 |
| 92497137 | Kennewick | 100576 | 493357 | TRUAX BP #58 | | 4819 W CLEARWATER AVE | 99336 | 10/1/1994 | 7/13/1994 | Cleanup Started | Soil | 46.21224 | 119.18495 |
| 92497137 | Kennewick | 100576 | 493357 | TRUAX BP #58 | | 4819 W CLEARWATER AVE | 99336 | 10/1/1994 | 4/20/2000 | Reported Cleaned Up | Soil | 46.21224 | 119.18495 |
| 94491149 | Kennewick | 4643 | 3394 | PETROLEUM PUMP COMPANY INC | | 109 E 19TH | 993375422 | 12/9/1991 | 11/27/1991 | Cleanup Started | Soil | 46.19098 | 119.11501 |
| 94491149 | Kennewick | 4643 | 3394 | PETROLEUM PUMP COMPANY INC | | 109 E 19TH | 993375422 | 12/9/1991 | 4/27/2000 | Reported Cleaned Up | Soil | 46.19098 | 119.11501 |
| 95584767 | Kennewick | 10758 | 404369 | LAYRITE PRODUCTS COMPANY | | N 307 DAYTON | 99336 | 6/30/1994 | 6/30/1994 | Cleanup Started | Soil | 46.21225 | 119.12232 |
| 95584767 | Kennewick | 10758 | 404369 | LAYRITE PRODUCTS COMPANY | | N 307 DAYTON | 99336 | 6/30/1994 | 7/23/1994 | Reported Cleaned Up | Soil | 46.21225 | 119.12232 |
| 97643965 | Kennewick | 11152 | 404517 | HILAND TEXACO/CLOSED | | 2718 W KENNEWICK AVE | 993363121 | 2/5/1992 | 9/27/1992 | Cleanup Started | Soil | 46.20962 | 119.158 |
| 97643965 | Kennewick | 11152 | 404517 | HILAND TEXACO/CLOSED | | 2718 W KENNEWICK AVE | 993363121 | 2/5/1992 | 4/27/2000 | Reported Cleaned Up | Soil | 46.20962 | 119.158 |
| 98555585 | Kennewick | 11003 | 3332 | CITY OF KENNEWICK-CITY CORPORATION YRD | CITY OF KENNEWICK-MAINTENANCE DEPT | 414 E TENTH AVENUE | 993366402 | 7/10/1990 | 7/10/1990 | Cleanup Started | Soil | 46.19798 | 119.10914 |
| 98555585 | Kennewick | 11003 | 3332 | CITY OF KENNEWICK-CITY CORPORATION YRD | CITY OF KENNEWICK-MAINTENANCE DEPT | 414 E TENTH AVENUE | 993366402 | 7/10/1990 | 11/26/1993 | Reported Cleaned Up | Soil | 46.19798 | 119.10914 |

# APPENDIX B

# Laboratory Certificates of Analysis for April 2005 Water Quality Data

**Analytical Data Package Prepared For**

# STL SEATTLE

**127528**

**Radiochemical Analysis By**

## STL Richland

*2800 G.W. Way, Richland Wa, 99354, (509)-375-3131.*

**Assigned Laboratory Code:**

*Data Package Contains* 17 *Pages*

**Report No.: 29049**

| SDG No. | Order No. | Client Sample ID (List Order) | Lot-Sa No. | Work Order | Report DB ID | Batch No. |
|---|---|---|---|---|---|---|
| 28817 | | BRINKLEY-E101 | J5D260349-1 | G88EQ1AG | 9G88EQ10 | 5125143 |
| | | BRINKLEY-E101 | J5D260349-1 | G88EQ1AD | 9G88EQ10 | 5125154 |
| | | BRINKLEY-E101 | J5D260349-1 | G88EQ1AF | 9G88EQ10 | 5125157 |
| | | BRINKLEY-E101 | J5D260349-1 | G88EQ1AE | 9G88EQ10 | 5125158 |
| | | BRINKLEY-E101 | J5D260349-1 | G88EQ1AA | 9G88EQ10 | 5125164 |
| | | BRINKLEY-E101 | J5D260349-1 | G88EQ2AC | 9G88EQ20 | 5159481 |
| | | SOURCE-042605 | J5D260349-2 | G88E01AG | 9G88E010 | 5125143 |
| | | SOURCE-042605 | J5D260349-2 | G88E01AD | 9G88E010 | 5125154 |
| | | SOURCE-042605 | J5D260349-2 | G88E01AF | 9G88E010 | 5125157 |
| | | SOURCE-042605 | J5D260349-2 | G88E01AE | 9G88E010 | 5125158 |
| | | SOURCE-042605 | J5D260349-2 | G88E01AA | 9G88E010 | 5125164 |
| | | SOURCE-042605 | J5D260349-2 | G88E02AC | 9G88E020 | 5159481 |

SEVERN TRENT STL

**STL Richland**
2800 George Washington Way
Richland, WA 99354

Tel: 509 375 3131 Fax: 509 375 5590
www.stl-inc.com

# Certificate of Analysis

June 23, 2005

STL Seattle
5755 8th Street E.
Tacoma, WA 98424

Attention: Katie Downie

| | | |
|---|---|---|
| Date Received | : | April 26, 2005 |
| Sample Number/Matrix | : | Two (2) Waters |
| SDG Number | : | 28817 |
| Project Number | : | 127528 |

## CASE NARRATIVE

### I. Introduction

On April 26, 2005, two water samples were received at the STL Richland (STLR) laboratory for radiochemical analysis. Upon receipt, the samples were assigned an STLR identification number as described on the cover page of the Analytical Data Package. The samples were assigned to Lot Number J5D260349.

### II. Sample Receipt

The samples were received in good condition, and no anomalies were noted during check-in.

### III. Analytical Results/Methodology

The analytical results for this report are presented by laboratory sample ID. Each set of data includes sample identification information; analytical results and the appropriate associated statistical uncertainties.

The requested analyses were:

**Gas Proportional Counting**
Gross Alpha by method RICH-RC-5014 (EPA 900.0)
Gross Beta by method RICH-RC-5014 (EPA 900.0)
Radium-228 by method RICH-RC-5005 (EPA 904.0)
Total Strontium by method RICH-RC-5006 (EPA 905.0)
**Alpha Scintillation Counting**
Radium-226 by method RICH-RC-5027 (EPA 903.1)
**Liquid Scintillation Counting**
Tritium by method RICH-RC-5007

## IV. Quality Control

The analytical result for each analysis performed includes a minimum of one laboratory control sample (LCS), and one reagent blank sample analysis. Any exceptions have been noted in the "Comments" section.

## V. Comments

### Gas Proportional Counting

Gross Alpha by method RICH-RC-5013 (EPA 900.0):
The LCS recovery was 72% on the first count due to counting statistics. The LCS was recounted and the data are accepted. Except as noted, the LCS, batch blank, sample, and sample duplicate results are within laboratory acceptance limits.

Gross Beta by method RICH-RC-5014 (EPA 900.0):
The LCS, batch blank, sample and sample duplicate results are within laboratory acceptance limits.

Radium-228 by method RICH-RC-5005 (EPA 904.0):
The batch was reanalyzed since the duplicate agreement was outside acceptance limits. The reanalysis batch is acceptable. Except as noted, the LCS, batch blank, sample, and sample duplicate results are within acceptance limits.

Total Strontium by method RICH-RC-5006 (EPA 905.0):
The LCS, batch blank, sample and sample duplicate results are within acceptance limits.

### Alpha Scintillation Counting

Radium-226 by method RICH-RC-5027 (EPA 903.1):
The LCS, batch blank, sample and sample duplicate results are within acceptance limits.

### Liquid Scintillation Counting

Tritium by method RICH-RC-5007:
The LCS, batch blank, sample, and sample duplicate results are within acceptance limits.

I certify that this Certificate of Analysis is in compliance with the SOW, both technically and for completeness, for other than the conditions detailed above. The Laboratory Manager or a designee, as verified by the following signature has authorized release of the data contained in this hard copy data package.

Reviewed and approved:

Sandra Seger
for Becky Warrington
Project Manager

## Drinking Water Method Cross References

| | DRINKING WATER ASTM METHOD CROSS REFERENCES | |
|---|---|---|
| | | |
| **Referenced Method** | **Isotope(s)** | **STL Richland's SOP number** |
| EPA 901.1 | Cs-134, I-131 | RICH-RC-5017 |
| EPA 900.0 | Alpha & Beta | RICH-RC-5014 |
| EPA 903.1 | Ra-226 | RICH-RC-5005 |
| EPA 904.0 | Ra-228 | RICH-RC-5005 |
| EPA 905.0 | Sr89/90 | RICH-RC-5006 |
| ASTM D2460 | Total Radium | RICH-RC-5027 |
| Standard Method 7500-U-C & ASTM D5174 | Uranium | RICH-RC-5058 |
| EPA 906.0 | Tritium | RICH-RC-5007 |
| | | |
| | | |
| | | |
| | | |
| NOTE: | | |
| The Gross Alpha LCS is prepared with Am-241 (unless otherwise specified in the case narrative) | | |
| The Gross Beta LCS is prepared with Sr/Y-90 (unless otherwise specified in the case narrative) | | |

## Uncertainty Estimation

STL Richland has adopted the internationally accepted approach to estimating uncertainties described in "NIST Technical Note 1297, 1994 Edition". The approach, "Law of Propagation of Errors", involves the identification of all variables in an analytical method which are used to derive a result. These variables are related to the analytical result (R) by some functional relationship, R = constants * f(x,y,z,...). The components (x,y,z) are evaluated to determine their contribution to the overall method uncertainty. The individual component uncertainties ($u_i$) are then combined using a statistical model that provides the most probable overall uncertainty value. All component uncertainties are categorized as type A, evaluated by statistical methods, or type B, evaluated by other means. Uncertainties not included in the components, such as sample homogeneity, are combined with the component uncertainty as the square root of the sum-of-the-squares of the individual uncertainties. The uncertainty associated with the derived result is the combined uncertainty ($u_c$) multiplied by the coverage factor (1,2, or 3).

When three or more sample replicates are used to derive the analytical result, the type A uncertainty is the standard deviation of the mean value ($S/\sqrt{n}$), where S is the standard deviation of the derived results. The type B uncertainties are all other random or non-random components that are not included in the standard deviation.

The derivation of the general "Law of Propagation of Errors" equations and specific example are available on request.

# Report Definitions

| | |
|---|---|
| **Action Lev** | An agreed upon activity level used to trigger some action when the final result is greater than or equal to the Action Level. Often the Action Level is related to the Decision Limit. |
| **Batch** | The QC preparation batch number that relates laboratory samples to QC samples that were prepared and analyzed together. |
| **Bias** | Defined by the equation (Result/Expected)-1 as defined by ANSI N13.30. |
| **COC No** | Chain of Custody Number assigned by the Client or STL Richland. |
| **Count Error (#s)** | Poisson counting statistics of the gross sample count and background. The uncertainty is absolute and in the same units as the result. For Liquid Scintillation Counting (LSC) the batch blank count is the background. |
| **Total Uncert (#s)**<br>***$u_c$ - Combined Uncertainty.*** | All known uncertainties associated with the preparation and analysis of the sample are propagated to give a measure of the uncertainty associated with the result, *$u_c$ the combined uncertainty*. The uncertainty is absolute and in the same units as the result. |
| **(#s), Coverage Factor** | The coverage factor defines the width of the confidence interval, 1, 2 or 3 standard deviations. |
| **CRDL (RL)** | Contractual Required Detection Limit as defined in the Client's Statement Of Work or STL Richland "default" nominal detection limit. Often referred to the reporting level (RL) |
| **Lc** | Decision Level based on instrument background or blank, adjusted by the Efficiency, Chemical Yield, and Volume associated with the sample. The Type I error probability is approximately 5%. Lc=(1.645 * Sqrt(2*(BkgrndCnt/BkgrndCntMin)/SCntMin)) * (ConvFct/(Eff*Yld*Abn*Vol) * IngrFct). For LSC methods the batch blank is used as a measure of the background variability. Lc cannot be calculated when the background count is zero. |
| **Lot-Sample No** | The number assigned by the LIMS software to track samples received on the same day for a given client. The sample number is a sequential number assigned to each sample in the Lot. |
| **MDC\|MDA** | Detection Level based on instrument background or blank, adjusted by the Efficiency, Chemical Yield, and Volume with a Type I and II error probability of approximately 5%. MDC = (4.65 * Sqrt((BkgrndCnt/BkgrndCntMin)/SCntMin) + 2.71/SCntMin) * (ConvFct/(Eff * Yld * Abn * Vol) * IngrFct). For LSC methods the batch blank is used as a measure of the background variability. |
| **Primary Detector** | The instrument identifier associated with the analysis of the sample aliquot. |
| **Ratio U-234/U-238** | The U-234 result divided by the U-238 result. The U-234/U-238 ratio for natural uranium in NIST SRM 4321C is 1.038. |
| **Rst/MDC** | Ratio of the Result to the MDC. A value greater than 1 may indicate activity above background at a high level of confidence. Caution should be used when applying this factor and it should be used in concert with the qualifiers associated with the result. |
| **Rst/TotUcert** | Ratio of the Result to the Total Uncertainty. If the uncertainty has a coverage factor of 2 a value greater than 1 may indicate activity above background at approximately the 95% level of confidence assuming a two-sided confidence interval. Caution should be used when applying this factor and it should be used in concert with the qualifiers associated with the result. |
| **Report DB No** | Sample Identifier used by the report system. The number is based upon the first five digits of the **Work Order** Number. |
| **RER** | The equation Replicate Error Ratio = (S-D)/[sqrt(TPUs$^2$ + TPUd$^2$)] as defined by ICPT BOA where S is the original sample result, D is the result of the duplicate, TPUs is the total uncertainty of the original sample and TPUd is the total uncertainty of the duplicate sample. |
| **SDG** | Sample Delivery Group Number assigned by the Client or assigned by STL Richland upon sample receipt. |
| **Sum Rpt Alpha Spec Rst(s)** | The sum of the reported alpha spec results for tests derived from the same sample excluding duplicate result where the results are in the same units. |
| **Work Order** | The LIMS software assign test specific identifier. |
| **Yield** | The recovery of the tracer added to the sample such as Pu-242 used to trace a Pu-239/40 method. |

# Sample Results Summary

## STL Richland

Ordered by Method, Batch No., Client Sample ID.

**Date:** 23-Jun-05

**Report No.** : 29049

**SDG No:** 28817

| Batch | Client Id Work Order | Parameter | Result +- Uncertainty ( 2s) | Qual | Units | Yield | MDC or MDA | CRDL | RER2 |
|---|---|---|---|---|---|---|---|---|---|
| **5125158 RICHRC5006** | | | | | | | | | |
| | BRINKLEY-E101 | | | | | | | | |
| | G88EQ1AE | STRONTIUM | -4.71E-01 +- 9.2E-01 | U | pCi/L | 95% | 2.32E+00 | 5.00E+00 | |
| | SOURCE-042605 | | | | | | | | |
| | G88E01AE | STRONTIUM | 2.82E-01 +- 9.8E-01 | U | pCi/L | 95% | 2.26E+00 | 5.00E+00 | |
| | SOURCE-042605 DUP | | | | | | | | |
| | G88E01AH | STRONTIUM | -2.32E-01 +- 9.3E-01 | U | pCi/L | 95% | 2.31E+00 | 5.00E+00 | 0.8 |
| **5125143 RICHRC5014** | | | | | | | | | |
| | BRINKLEY-E101 | | | | | | | | |
| | G88EQ1AG | BETA | 3.94E+00 +- 1.9E+00 | J | pCi/L | 100% | 3.39E+00 | 4.00E+00 | |
| | GW-85 DUP | | | | | | | | |
| | G9LLG1AC | BETA | 4.92E+02 +- 1.6E+02 | | pCi/L | 100% | 1.79E+02 | 2.00E+02 | 1.0 |
| | SOURCE-042605 | | | | | | | | |
| | G88E01AG | BETA | 6.15E+00 +- 2.0E+00 | | pCi/L | 100% | 2.78E+00 | 4.00E+00 | |
| **5125157 RICHRC5014** | | | | | | | | | |
| | BRINKLEY-E101 | | | | | | | | |
| | G88EQ1AF | ALPHA | 2.66E+00 +- 1.9E+00 | J | pCi/L | 100% | 2.30E+00 | 3.00E+00 | |
| | BRINKLEY-E101 DUP | | | | | | | | |
| | G88EQ1AJ | ALPHA | 4.68E+00 +- 2.3E+00 | | pCi/L | 100% | 1.45E+00 | 3.00E+00 | 1.4 |
| | SOURCE-042605 | | | | | | | | |
| | G88E01AF | ALPHA | 7.55E+00 +- 3.4E+00 | | pCi/L | 100% | 2.50E+00 | 3.00E+00 | |
| **5125164 RICHRC5005** | | | | | | | | | |
| | 0SM0SIS INV. DUP | | | | | | | | |
| | G9E6X1AJ | RA-226 | 3.81E-02 +- 7.4E-02 | U | pCi/L | 100% | 1.33E-01 | 1.00E+00 | |
| | BRINKLEY-E101 | | | | | | | | |
| | G88EQ1AA | RA-226 | 5.30E-02 +- 7.6E-02 | U | pCi/L | 100% | 1.30E-01 | 1.00E+00 | |
| | SOURCE-042605 | | | | | | | | |
| | G88E01AA | RA-226 | 2.28E-01 +- 1.2E-01 | J | pCi/L | 100% | 1.40E-01 | 1.00E+00 | |
| **5159481 RICHRC5005** | | | | | | | | | |
| | BRINKLEY-E101 | | | | | | | | |
| | G88EQ2AC | RA-228 | 7.58E-01 +- 3.4E-01 | J | pCi/L | 72% | 5.19E-01 | 3.00E+00 | |
| | SOURCE-042605 | | | | | | | | |
| | G88E02AC | RA-228 | 6.55E-01 +- 2.9E-01 | J | pCi/L | 87% | 4.33E-01 | 3.00E+00 | |
| | SOURCE-042605 DUP | | | | | | | | |
| | G88E01AJ | RA-228 | 1.21E+00 +- 4.0E-01 | J | pCi/L | 84% | 4.92E-01 | 3.00E+00 | 2.3 |
| **5125154 RICHRC5007** | | | | | | | | | |
| | BRINKLEY-E101 | | | | | | | | |
| | G88EQ1AD | H-3 | 2.54E+02 +- 1.3E+02 | U | pCi/L | 100% | 2.60E+02 | 4.00E+02 | |
| | BRINKLEY-E101 DUP | | | | | | | | |
| | G88EQ1AH | H-3 | 1.40E+02 +- 1.3E+02 | U | pCi/L | 100% | 2.61E+02 | 4.00E+02 | 1.2 |

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RER2 - Replicate Error Ratio = (S-D)/[sqrt(sq(TPUs)+sq(TPUd))] as defined by ICPT BOA.

J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# Sample Results Summary

# STL Richland

**Date:** 23-Jun-05

Ordered by Method, Batch No., Client Sample ID.

**Report No. :** 29049

**SDG No:** 28817

| Batch | Client Id<br>Work Order | Parameter | Result +- Uncertainty ( 2s) | Qual | Units | Yield | MDC or MDA | CRDL | RER2 |
|---|---|---|---|---|---|---|---|---|---|
| 5125154 | **RICHRC5007** | | | | | | | | |
| | SOURCE-042605 | | | | | | | | |
| | G88E01AD | H-3 | 1.52E+02 +- 1.3E+02 | U | pCi/L | 100% | 2.61E+02 | 4.00E+02 | |

**No. of Results:** 18

STL Richland

rptSTLRchSaSum
mary2 V4.13 A97

RER2 - Replicate Error Ratio = (S-D)/[sqrt(sq(TPUs)+sq(TPUd))] as defined by ICPT BOA.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# QC Results Summary

# STL Richland

Ordered by Method, Batch No, QC Type,.

**Date:** 23-Jun-05

**Report No.** : 29049

**SDG No.:** 28817

| Batch<br>Work Order | Parameter | Result +- Uncertainty ( 2s) | Qual | Units | Yield | Recovery | Bias | MDC\|MDA |
|---|---|---|---|---|---|---|---|---|
| **RICHRC5006** | | | | | | | | |
| 5125158 BLANK QC | | | | | | | | |
| G9V4L1AA | STRONTIUM | -1.28E+00 +- 9.1E-01 | U | pCi/L | 94% | | | 2.41E+00 |
| 5125158 LCS | | | | | | | | |
| G9V4L1AC | STRONTIUM | 5.95E+01 +- 1.7E+01 | | pCi/L | 94% | 88% | -0.1 | 2.28E+00 |
| **RICHRC5014** | | | | | | | | |
| 5125143 BLANK QC | | | | | | | | |
| G9V3L1AA | BETA | 1.99E-01 +- 7.6E-01 | U | pCi/L | 100% | | | 1.52E+00 |
| 5125143 LCS | | | | | | | | |
| G9V3L1AC | BETA | 3.94E+01 +- 6.5E+00 | | pCi/L | 100% | 96% | 0.0 | 1.69E+00 |
| **RICHRC5014** | | | | | | | | |
| 5125157 BLANK QC | | | | | | | | |
| G9V4A1AA | ALPHA | -1.28E-01 +- 3.4E-01 | U | pCi/L | 100% | | | 1.14E+00 |
| 5125157 LCS | | | | | | | | |
| G9V4A2AC | ALPHA | 1.98E+01 +- 5.0E+00 | | pCi/L | 100% | 83% | -0.2 | 9.54E-01 |
| **RICHRC5005** | | | | | | | | |
| 5125164 BLANK QC | | | | | | | | |
| G9V4N1AA | RA-226 | 3.55E-02 +- 8.1E-02 | U | pCi/L | 100% | | | 1.47E-01 |
| 5125164 LCS | | | | | | | | |
| G9V4N1AC | RA-226 | 1.13E+00 +- 2.9E-01 | | pCi/L | 100% | 82% | -0.2 | 1.01E-01 |
| **RICHRC5005** | | | | | | | | |
| 5159481 BLANK QC | | | | | | | | |
| HC7N41AA | RA-228 | 4.88E-01 +- 2.7E-01 | J | pCi/L | 88% | | | 4.60E-01 |
| 5159481 LCS | | | | | | | | |
| HC7N41AC | RA-228 | 5.85E+00 +- 1.3E+00 | | pCi/L | 88% | 117% | 0.2 | 4.78E-01 |
| **RICHRC5007** | | | | | | | | |
| 5125154 BLANK QC | | | | | | | | |
| G9V371AA | H-3 | 1.45E+02 +- 1.3E+02 | U | pCi/L | 100% | | | 2.64E+02 |
| G9V371AD | H-3 | 9.21E+01 +- 1.2E+02 | U | pCi/L | 100% | | | 2.63E+02 |
| 5125154 LCS | | | | | | | | |
| G9V371AE | H-3 | 2.40E+03 +- 2.4E+02 | | pCi/L | 100% | 88% | -0.1 | 2.61E+02 |
| G9V371AC | H-3 | 2.79E+03 +- 2.6E+02 | | pCi/L | 100% | 103% | 0.0 | 2.62E+02 |

**No. of Results:** 14

Bias - (Result/Expected)-1 as defined by ANSI N13.30.

J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# FORM I

# SAMPLE RESULTS

**Date:** 23-Jun-05

| | | | | | |
|---|---|---|---|---|---|
| **Lab Name:** | STL Richland | **SDG:** | 28817 | **Collection Date:** | 4/25/2005 11:15:00 AM |
| **Lot-Sample No.:** | J5D260349-1 | **Report No. :** | 29049 | **Received Date:** | 4/26/2005 3:15:00 PM |
| **Client Sample ID:** | BRINKLEY-E101 | **COC No. :** | | **Matrix:** | WATER |

127528

Ordered by Client Sample ID, Batch No.

| Parameter | Result | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Action Lev | Rpt Unit, Lc | Yield CRDL(RL) | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125143 | RICHRC5014 | | | **Work Order:** | G88EQ1AG | | **Report DB ID:** | 9G88EQ10 | | | | |
| BETA | **3.94E+00** | J | 1.8E+00 | 1.9E+00 | 3.39E+00 | pCi/L | 100% | *(1.2)* | 5/12/05 07:42 p | | 0.165 | GPC26B |
| | | | | | | 1.61E+00 | 4.00E+00 | *(4.1)* | | | L | |
| **Batch:** 5125154 | RICHRC5007 | | | **Work Order:** | G88EQ1AD | | **Report DB ID:** | 9G88EQ10 | | | | |
| H-3 | **2.54E+02** | U | 1.2E+02 | 1.3E+02 | 2.60E+02 | pCi/L | 100% | *0.97* | 5/12/05 01:57 a | | 0.01 | LSC6 |
| | | | | | | 1.20E+02 | 4.00E+02 | *(3.8)* | | | L | |
| **Batch:** 5125157 | RICHRC5014 | | | **Work Order:** | G88EQ1AF | | **Report DB ID:** | 9G88EQ10 | | | | |
| ALPHA | **2.66E+00** | J | 1.8E+00 | 1.9E+00 | 2.30E+00 | pCi/L | 100% | *(1.2)* | 5/12/05 08:25 p | | 0.1962 | GPC10A |
| | | | | | | 8.22E-01 | 3.00E+00 | *(2.9)* | | | L | |
| **Batch:** 5125158 | RICHRC5006 | | | **Work Order:** | G88EQ1AE | | **Report DB ID:** | 9G88EQ10 | | | | |
| STRONTIUM | **-4.71E-01** | U | 9.1E-01 | 9.2E-01 | 2.32E+00 | pCi/L | 95% | *-0.2* | 5/23/05 06:54 p | | 0.20005 | GPC31C |
| | | | | | | 1.08E+00 | 5.00E+00 | *-(1.)* | | | L | |
| **Batch:** 5125164 | RICHRC5005 | | | **Work Order:** | G88EQ1AA | | **Report DB ID:** | 9G88EQ10 | | | | |
| RA-226 | **5.30E-02** | U | 7.5E-02 | 7.6E-02 | 1.30E-01 | pCi/L | 100% | *0.41* | 5/29/05 12:09 p | | 1.006 | ASCLMA |
| | | | | | | 5.47E-02 | 1.00E+00 | *(1.4)* | | | L | |
| **Batch:** 5159481 | RICHRC5005 | | | **Work Order:** | G88EQ2AC | | **Report DB ID:** | 9G88EQ20 | | | | |
| RA-228 | **7.58E-01** | J | 3.1E-01 | 3.4E-01 | 5.19E-01 | pCi/L | 72% | *(1.5)* | 6/16/05 06:12 a | | 1.0631 | GPC5B |
| | | | | | | 2.45E-01 | 3.00E+00 | *(4.5)* | | | L | |

**No. of Results:** 6 **Comments:**

STL Richland
rptSTLRchSample
V4.13 A97

**MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.**
**J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.**
**U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.**

# FORM I

# SAMPLE RESULTS

**Date:** 23-Jun-05

**Lab Name:** STL Richland
**Lot-Sample No.:** J5D260349-2
**Client Sample ID:** SOURCE-042605
127528

**SDG:** 28817
**Report No. :** 29049
**COC No. :**

**Collection Date:** 4/25/2005 11:15:00 AM
**Received Date:** 4/26/2005 3:15:00 PM
**Matrix:** WATER

Ordered by Client Sample ID, Batch No.

| Parameter | Result | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Action Lev | Rpt Unit, Lc | Yield CRDL(RL) | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125143 | RICHRC5014 | | | **Work Order:** | G88E01AG | | **Report DB ID:** | 9G88E010 | | | | |
| BETA | 6.15E+00 | | 1.7E+00 | 2.0E+00 | 2.78E+00 | pCi/L | 100% | *(2.2)* | 5/12/05 07:42 p | | 0.1906 | GPC26C |
| | | | | | | 1.32E+00 | 4.00E+00 | *(6.2)* | | | L | |
| **Batch:** 5125154 | RICHRC5007 | | | **Work Order:** | G88E01AD | | **Report DB ID:** | 9G88E010 | | | | |
| H-3 | 1.52E+02 | U | 1.1E+02 | 1.3E+02 | 2.61E+02 | pCi/L | 100% | *0.58* | 5/12/05 03:22 a | | 0.01 | LSC6 |
| | | | | | | 1.20E+02 | 4.00E+02 | *(2.4)* | | | L | |
| **Batch:** 5125157 | RICHRC5014 | | | **Work Order:** | G88E01AF | | **Report DB ID:** | 9G88E010 | | | | |
| ALPHA | 7.55E+00 | | 3.0E+00 | 3.4E+00 | 2.50E+00 | pCi/L | 100% | *(3.)* | 5/12/05 08:25 p | | 0.1951 | GPC10D |
| | | | | | | 8.87E-01 | 3.00E+00 | *(4.5)* | | | L | |
| **Batch:** 5125158 | RICHRC5006 | | | **Work Order:** | G88E01AE | | **Report DB ID:** | 9G88E010 | | | | |
| STRONTIUM | 2.82E-01 | U | 9.8E-01 | 9.8E-01 | 2.26E+00 | pCi/L | 95% | *0.12* | 5/23/05 06:54 p | | 0.20003 | GPC31D |
| | | | | | | 1.05E+00 | 5.00E+00 | *0.57* | | | L | |
| **Batch:** 5125164 | RICHRC5005 | | | **Work Order:** | G88E01AA | | **Report DB ID:** | 9G88E010 | | | | |
| RA-226 | 2.28E-01 | J | 1.1E-01 | 1.2E-01 | 1.40E-01 | pCi/L | 100% | *(1.6)* | 5/29/05 12:07 p | | 1.0057 | ASCMMA |
| | | | | | | 5.97E-02 | 1.00E+00 | *(3.9)* | | | L | |
| **Batch:** 5159481 | RICHRC5005 | | | **Work Order:** | G88E02AC | | **Report DB ID:** | 9G88E020 | | | | |
| RA-228 | 6.55E-01 | J | 2.6E-01 | 2.9E-01 | 4.33E-01 | pCi/L | 87% | *(1.5)* | 6/16/05 06:12 a | | 1.0156 | GPC5D |
| | | | | | | 2.04E-01 | 3.00E+00 | *(4.5)* | | | L | |

**No. of Results:** 6 **Comments:**

**STL Richland**
**rptSTLRchSample**
V4.13 A97
0

**MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.**
**J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.**
**U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.**

# FORM II

**Date:** 23-Jun-05

# DUPLICATE RESULTS

| | | | | | |
|---|---|---|---|---|---|
| **Lab Name:** | STL Richland | **SDG:** | 28833 | **Collection Date:** | 4/25/2005 11:15:00 AM |
| **Lot-Sample No.:** | J5D280329-1 | **Report No. :** | 29049 | **Received Date:** | 4/28/2005 10:30:00 AM |
| **Client Sample ID:** | 0SM0SIS INV. DUP | **COC No. :** | | **Matrix:** | WATER |

| Parameter | Result, Orig Rst | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Action Lev | Rpt Unit, CRDL | Yield | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125164 | RICHRC5005 | | | **Work Order:** | G9E6X1AJ | **Report DB ID:** | | G9E6X1JR | **Orig Sa DB ID:** | 9G9E6X10 | | |
| RA-226 | 3.81E-02 | U | 7.4E-02 | 7.4E-02 | 1.33E-01 | pCi/L | 100% | 0.29 | 5/29/05 12:12 p | | 0.9914 | ASCNMB |
| | 1.33E-01 | J | **RER2 1.6** | | | 1.00E+00 | | (1.) | | | L | |

**No. of Results:** 1 **Comments:**

**STL Richland**
rptSTLRchDupV4.1
3 A97

RER2 - Replicate Error Ratio = (S-D)/[sqrt(sq(TPUs)+sq(TPUd))] as defined by ICPT BOA.

MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.

J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# FORM II

**Date:** 23-Jun-05

# DUPLICATE RESULTS

| | | | | | |
|---|---|---|---|---|---|
| **Lab Name:** | **STL Richland** | **SDG:** | 28817 | **Collection Date:** | 4/26/2005 11:10:00 AM |
| **Lot-Sample No.:** | **J5D260349-1** | **Report No. :** | 29049 | **Received Date:** | 4/26/2005 3:15:00 PM |
| **Client Sample ID:** | **BRINKLEY-E101 DUP** | **COC No. :** | | **Matrix:** | WATER |

| Parameter | Result, Orig Rst | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Action Lev | Rpt Unit, CRDL | Yield | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125154 | RICHRC5007 | | | **Work Order:** G88EQ1AH | | **Report DB ID:** G88EQ1HR | | | **Orig Sa DB ID:** 9G88EQ10 | | | |
| H-3 | 1.40E+02 | U | 1.1E+02 | 1.3E+02 | 2.61E+02 | pCi/L | 100% | 0.54 | 5/12/05 02:39 a | | 0.01 | LSC6 |
| | 2.54E+02 | U | **RER2** | **1.2** | | 4.00E+02 | | (2.2) | | | L | |
| **Batch:** 5125157 | RICHRC5014 | | | **Work Order:** G88EQ1AJ | | **Report DB ID:** G88EQ1JR | | | **Orig Sa DB ID:** 9G88EQ10 | | | |
| ALPHA | 4.68E+00 | | 2.1E+00 | 2.3E+00 | 1.45E+00 | pCi/L | 100% | (3.2) | 5/12/05 08:25 p | | 0.2008 | GPC10B |
| | 2.66E+00 | J | **RER2** | **1.4** | | 3.00E+00 | | (4.) | | | L | |

**No. of Results:** 2 **Comments:**

RER2 - Replicate Error Ratio = (S-D)/[sqrt(sq(TPUs)+sq(TPUd))] as defined by ICPT BOA.

MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.

J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# FORM II

**Date:** 23-Jun-05

# DUPLICATE RESULTS

| | | | | | |
|---|---|---|---|---|---|
| **Lab Name:** | STL Richland | **SDG:** | 28867 | **Collection Date:** | 3/29/2005 10:45:00 AM |
| **Lot-Sample No.:** | J5D300244-1 | **Report No. :** | 29049 | **Received Date:** | 4/29/2005 4:00:00 PM |
| **Client Sample ID:** | GW-85 DUP | **COC No. :** | | **Matrix:** | WATER |

| Parameter | Result, Orig Rst | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Action Lev | Rpt Unit, CRDL | Yield | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125143 | RICHRC5014 | | | **Work Order:** G9LLG1AC | | **Report DB ID:** G9LLG1CR | | | **Orig Sa DB ID:** 9G9LLG10 | | | |
| BETA | 4.92E+02 | | 1.1E+02 | 1.6E+02 | 1.79E+02 | pCi/L | 100% | (2.7) | 5/12/05 05:03 p | | 0.002 | GPC27D |
| | 3.89E+02 | | **RER2 1.0** | | | 2.00E+02 | | (6.3) | | | L | |

**No. of Results:** 1 **Comments:**

**STL Richland** RER2 - Replicate Error Ratio = (S-D)/[sqrt(sq(TPUs)+sq(TPUd))] as defined by ICPT BOA.

**rptSTLRchDupV4.1** MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.

3 3 97

# FORM II

**Date:** 23-Jun-05

# DUPLICATE RESULTS

| | | | | | |
|---|---|---|---|---|---|
| **Lab Name:** | STL Richland | **SDG:** | 28817 | **Collection Date:** | 4/26/2005 12:40:00 PM |
| **Lot-Sample No.:** | J5D260349-2 | **Report No. :** | 29049 | **Received Date:** | 4/26/2005 3:15:00 PM |
| **Client Sample ID:** | SOURCE-042605 DUP | **COC No. :** | | **Matrix:** | WATER |

| Parameter | Result, Orig Rst | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Action Lev | Rpt Unit, CRDL | Yield | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125158 | RICHRC5006 | | | **Work Order:** | G88E01AH | **Report DB ID:** | G88E01HR | | **Orig Sa DB ID:** 9G88E010 | | | |
| STRONTIUM | -2.32E-01 | U | 9.3E-01 | 9.3E-01 | 2.31E+00 | pCi/L | 95% | -0.1 | 5/23/05 06:54 p | | 0.20006 | GPC32A |
| | 2.82E-01 | U | **RER2** | **0.8** | | 5.00E+00 | | -0.5 | | | L | |
| **Batch:** 5159481 | RICHRC5005 | | | **Work Order:** | G88E01AJ | **Report DB ID:** | G88E01JR | | **Orig Sa DB ID:** 9G88E020 | | | |
| RA-228 | 1.21E+00 | J | 3.2E-01 | 4.0E-01 | 4.92E-01 | pCi/L | 84% | (2.5) | 6/16/05 06:12 a | | 1.015 | GPC5C |
| | 6.55E-01 | J | **RER2** | **2.3** | | 3.00E+00 | | (6.1) | | | L | |

**No. of Results:** 2 **Comments:**

**STL Richland**

rptSTLRchDupV4.1

3-A97

RER2 - Replicate Error Ratio = (S-D)/[sqrt(sq(TPUs)+sq(TPUd))] as defined by ICPT BOA.

MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.

J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# FORM II

**Date:** 23-Jun-05

# BLANK RESULTS

|  |  |  |  |
|---|---|---|---|
| **Lab Name:** | STL Richland | **SDG:** | 28817 |
| **Matrix:** | WATER | **Report No. :** | 29049 |

| Parameter | Result | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA, Lc | Rpt Unit, CRDL | Yield | Rst/MDC, Rst/TotUcert | Analysis, Prep Date | Total Sa Size | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125154 | RICHRC5007 |  |  | **Work Order:** | G9V371AA | **Report DB ID:** |  | G9V371AB |  |  |  |  |
| H-3 | 1.45E+02 | U | 1.1E+02 | 1.3E+02 | 2.64E+02 | pCi/L | 100% | 0.55 | 5/12/05 04:04 a |  | 0.01 | LSC6 |
|  |  |  |  |  | 1.21E+02 | 4.00E+02 |  | (2.3) |  |  | L |  |
| **Batch:** 5125154 | RICHRC5007 |  |  | **Work Order:** | G9V371AD | **Report DB ID:** |  | G9V371DX |  |  |  |  |
| H-3 | 9.21E+01 | U | 1.1E+02 | 1.2E+02 | 2.63E+02 | pCi/L | 100% | 0.35 | 5/12/05 05:28 a |  | 0.01 | LSC6 |
|  |  |  |  |  | 1.21E+02 | 4.00E+02 |  | (1.5) |  |  | L |  |
| **Batch:** 5125157 | RICHRC5014 |  |  | **Work Order:** | G9V4A1AA | **Report DB ID:** |  | G9V4A1AB |  |  |  |  |
| ALPHA | -1.28E-01 | U | 3.4E-01 | 3.4E-01 | 1.14E+00 | pCi/L | 100% | -0.11 | 5/13/05 08:04 a |  | 0.2061 | GPC11B |
|  |  |  |  |  | 4.46E-01 | 3.00E+00 |  | -0.75 |  |  | L |  |
| **Batch:** 5125143 | RICHRC5014 |  |  | **Work Order:** | G9V3L1AA | **Report DB ID:** |  | G9V3L1AB |  |  |  |  |
| BETA | 1.99E-01 | U | 7.6E-01 | 7.6E-01 | 1.52E+00 | pCi/L | 100% | 0.13 | 5/12/05 05:02 p |  | 0.2161 | GPC28D |
|  |  |  |  |  | 7.32E-01 | 4.00E+00 |  | 0.53 |  |  | L |  |
| **Batch:** 5125164 | RICHRC5005 |  |  | **Work Order:** | G9V4N1AA | **Report DB ID:** |  | G9V4N1AB |  |  |  |  |
| RA-226 | 3.55E-02 | U | 8.1E-02 | 8.1E-02 | 1.47E-01 | pCi/L | 100% | 0.24 | 5/29/05 01:12 p |  | 1.0062 | ASCNMC |
|  |  |  |  |  | 6.40E-02 | 1.00E+00 |  | 0.87 |  |  | L |  |
| **Batch:** 5159481 | RICHRC5005 |  |  | **Work Order:** | HC7N41AA | **Report DB ID:** |  | HC7N41AB |  |  |  |  |
| RA-228 | 4.88E-01 | J | 2.6E-01 | 2.7E-01 | 4.60E-01 | pCi/L | 88% | (1.1) | 6/16/05 06:12 a |  | 1.0133 | GPC6C |
|  |  |  |  |  | 2.17E-01 | 3.00E+00 |  | (3.6) |  |  | L |  |
| **Batch:** 5125158 | RICHRC5006 |  |  | **Work Order:** | G9V4L1AA | **Report DB ID:** |  | G9V4L1AB |  |  |  |  |
| STRONTIUM | -1.28E+00 | U | 8.4E-01 | 9.1E-01 | 2.41E+00 | pCi/L | 94% | -0.53 | 5/23/05 06:54 p |  | 0.20006 | GPC32C |
|  |  |  |  |  | 1.12E+00 | 5.00E+00 |  | -(2.8) |  |  | L |  |

**MDC|MDA,Lc - Detection, Decision Level based on instrument background or blank, adjusted by the sample Efficiency, Yield, and Volume.**

J Qual - No U|< qualifier has been assigned and the result is below the Reporting Limit, RL (CRDL) or Report Value is Estimated.

U Qual - Analyzed for, but the result is less than the Mdc/Mda|Total Uncert or gamma scan software did not identify the nuclide.

# FORM II

# LCS RESULTS

**Date:** 23-Jun-05

**Lab Name:** STL Richland

**Matrix:** WATER

**SDG:** 28817

**Report No. :** 29049

| Parameter | Result | Qual | Count Error ( 2 s) | Total Uncert( 2 s) | MDC\|MDA | Report Unit | Yield | Expected | Expected Uncert | Recovery, Bias | Analysis, Prep Date | Aliquot Size | Primary Detector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch:** 5125154 | RICHRC5007 | | | **Work Order:** G9V371AC | | | **Report DB ID:** G9V371CS | | | | | | |
| H-3 | 2.79E+03 | | 2.3E+02 | 2.6E+02 | 2.62E+02 | pCi/L | 100% | 2.72E+03 | 8.2E+01 | 103% | 5/12/05 04:46 a | 0.01 | LSC6 |
| | | | | | | | **Rec Limits:** | 70 | 130 | 0.0 | | L | |
| **Batch:** 5125154 | RICHRC5007 | | | **Work Order:** G9V371AE | | | **Report DB ID:** G9V371EM | | | | | | |
| H-3 | 2.40E+03 | | 2.2E+02 | 2.4E+02 | 2.61E+02 | pCi/L | 100% | 2.72E+03 | 8.2E+01 | 88% | 5/12/05 06:10 a | 0.01 | LSC6 |
| | | | | | | | **Rec Limits:** | 70 | 130 | -0.1 | | L | |
| **Batch:** 5125157 | RICHRC5014 | | | **Work Order:** G9V4A2AC | | | **Report DB ID:** G9V4A2CS | | | | | | |
| ALPHA | 1.98E+01 | | 2.8E+00 | 5.0E+00 | 9.54E-01 | pCi/L | 100% | 2.39E+01 | 7.8E-01 | 83% | 5/19/05 07:41 a | 0.1962 | GPC11A |
| | | | | | | | **Rec Limits:** | 70 | 130 | -0.2 | | L | |
| **Batch:** 5125143 | RICHRC5014 | | | **Work Order:** G9V3L1AC | | | **Report DB ID:** G9V3L1CS | | | | | | |
| BETA | 3.94E+01 | | 2.1E+00 | 6.5E+00 | 1.69E+00 | pCi/L | 100% | 4.09E+01 | 5.0E-01 | 96% | 5/12/05 05:09 p | 0.1975 | GPC31D |
| | | | | | | | **Rec Limits:** | 70 | 130 | 0.0 | | L | |
| **Batch:** 5125164 | RICHRC5005 | | | **Work Order:** G9V4N1AC | | | **Report DB ID:** G9V4N1CS | | | | | | |
| RA-226 | 1.13E+00 | | 1.9E-01 | 2.9E-01 | 1.01E-01 | pCi/L | 100% | 1.37E+00 | 6.9E-02 | 82% | 5/29/05 12:09 p | 1.0062 | ASCKME |
| | | | | | | | **Rec Limits:** | 70 | 130 | -0.2 | | L | |
| **Batch:** 5159481 | RICHRC5005 | | | **Work Order:** HC7N41AC | | | **Report DB ID:** HC7N41CS | | | | | | |
| RA-228 | 5.85E+00 | | 5.2E-01 | 1.3E+00 | 4.78E-01 | pCi/L | 88% | 5.00E+00 | 1.2E-01 | 117% | 6/16/05 07:10 a | 1.0031 | GPC6D |
| | | | | | | | **Rec Limits:** | 70 | 130 | 0.2 | | L | |
| **Batch:** 5125158 | RICHRC5006 | | | **Work Order:** G9V4L1AC | | | **Report DB ID:** G9V4L1CS | | | | | | |
| STRONTIUM | 5.95E+01 | | 4.0E+00 | 1.7E+01 | 2.28E+00 | pCi/L | 94% | 6.73E+01 | 8.0E-01 | 88% | 5/23/05 06:54 p | 0.2 | GPC32B |
| | | | | | | | **Rec Limits:** | 20 | 115 | -0.1 | | L | |

**No. of Results:** 7 **Comments:**

**STL Richland** Bias - **(Result/Expected)-1 as defined by ANSI N13.30.**

**rptSTLRchLcs**
**V4.13 A97**

# Chain of Custody Record

SDG# 28817

STL Seattle
5755 8th Street E.
Tacoma, WA 98424
Tel. 253-922-2310
Fax 253-922-5047
www.stl-inc.com

STL-S
JSD260349

5/24/05

SEVERN TRENT STL

Client: Aspect Consulting

Project Manager: Steve Germiat

Date: 4/26/05

Chain of Custody Number: 19040

Address: 811 First Ave, Suite 480

Telephone Number (Area Code)/Fax Number: (206) 838-5830

Lab Number:

Page ______ of ______

City: Seattle

State: WA

Zip Code: 98104

Site Contact:

Lab Contact:

Project Name and Location (State): Kennewick ASR

Carrier/Waybill Number:

Contract/Purchase Order/Quote No.:

| | | | Matrix | | | | | Containers & Preservatives | | | | | | | Analysis (Attach list if more space is needed) | | | | | | | | | | Special Instructions/ Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Air | Aqueous | Sed. | Soil | | Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/NaOH | | Gross Alpha | Gross Beta | Radium 226 | Radium 228 | Tritium | Strontium 90 | | 18 X LP<br>4X 200mL Ag | | | x2x200mLAg |
| Brinkley - E01 | 4/26/05 | 11:10 | G | 8 | 8 | EQ | | X | | X | | | | | X | X | X | X | X | X | | 11 Bottles | | | STL Richland |
| Source - 042605 | 4/26/05 | 12:40 | G | 8 | 8 | EO | | X | | X | | | | | X | X | X | X | X | X | | 11 Bottles | | | ″<br>2x200mLAg |

* See Attached - Full List

Cooler ☐ Yes ☐ No Cooler Temp:______

Possible Hazard Identification ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal ☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days) ☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☑ Other 28 Days

QC Requirements (Specify)

1. Relinquished By | Date 4/26/05 | Time 15:15
1. Received By | Date 4/26/05 | Time 15:45
2. Relinquished By | Date | Time
2. Received By | Date | Time
3. Relinquished By | Date | Time
3. Received By | Date | Time

Comments

**DISTRIBUTION:** *WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy*

STL8274-580 (12/02)

SEVERN TRENT STL

**STL Seattle**
5755 8th Street East
Tacoma, WA 98424

Tel: 253 922 2310
Fax: 253 922 5047
www.stl-inc.com

# TRANSMITTAL MEMORANDUM

DATE: June 3, 2005

TO: Steve Germiat
Aspect Consulting LLC
811 First Avenue, Suite 480
Seattle, WA 98104

PROJECT: Kennewick ASR

REPORT NUMBER: 127528 - Addendum

TOTAL NUMBER OF PAGES: ______

Enclosed are the haloacetic acid test results for two samples received at STL Seattle on April 27, 2005. The general chemistry data was submitted on May 11, 2005. The radiochemistry data is still pending.

The report consists of this transmittal memo and analytical data package supplied by Edge Analytical.

Should there be any questions regarding this report, please contact me at (253) 922-2310.

Sincerely,

Katie Downie

Katie Downie
Project Manager

---

# STL Seattle

Sample Identification:

| Lab. No. | Client ID | Date/Time Sampled | Matrix |
|---|---|---|---|
| 127528-1 | Brinkley -E01 | 04-26-05 11:10 | Liquid |
| 127528-2 | Source-042605 | 04-26-05 12:40 | Liquid |

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May 13, 2005

Katie Downie
STL Seattle
5755 8th St E
Tacoma, WA 98424

RE: 05-04641 - 127528

Dear Katie Downie,

Your project: 127528, was received on Thursday April 28, 2005.

All samples were analyzed within the accepted holding times, were appropriately preserved and were analyzed according to approved analytical protocols. The quality control data was within laboratory acceptance limits.

If you have questions phone me at 800 755-9295.

Respectfully Submitted,

L. J. Henderson, PhD
Laboratory Director

Enclosures Data Report
QC Reports
Chain of Custody

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# DISINFECTION BY-PRODUCT COMPOUNDS REPORT

Client Name: STL Seattle
5755 8th St E
Tacoma, WA 98424

Reference Number: 05-04641

Project: 127528

System Name:
System ID Number:
DOH Source Number:
Multiple Sources:
Sample Type:
Sample Purpose: Investigative or Other
Sample Location: Brinkley - E01
County:

Field ID: Brinkley - E01
Lab Number: 04610891
Date Collected: 4/26/2005
Date Extracted: 552_050502
Date Analyzed: 5/6/2005
Report Date: 5/13/2005
Analyst: CMH
Supervisor:

## EPA Method 552.2

| DOH# | COMPOUNDS | RESULTS | Units | SRL | Trigger | MCL | COMMENT |
|---|---|---|---|---|---|---|---|
| | **Halo-Acetic Acids** | | | | | | |
| | MONOCHLOROACETIC ACID | ND | ug/L | 2 | | | |
| | DICHLOROACETIC ACID | ND | ug/L | 1 | | | |
| | TRICHLOROACETIC ACID | ND | ug/L | 1 | | | |
| | MONOBROMOACETIC ACID | ND | ug/L | 1 | | | |
| | DIBROMOACETIC ACID | ND | ug/L | 1 | | | |
| | HAA(5) | ND | ug/L | 1 | 48 | 60 | |
| | **Other** | | | | | | |
| | BROMOCHLOROACETIC ACID | ND | ug/L | 1 | | | |

A Result of "ND" indicates that the compound was not detected above the Lab's Method Detection Limit - MDL.
Maximum Contaminant Level, maximum permissible level of a contaminant in water established by EPA, NPDWR. State Advisory Level (SAL) for Unregulated compounds.
A blank MCL or SAL value indicates a level is not currently established.
If a compound is detected > or = to the State Reporting Level, SRL, specified increased monitoring frequencies may occur per DOH.
Method Detection Limit is the lab's minimum concentration a compound can be measured and reported with 99% confidence that the compound concentration is greater than zero.
J - Estimated value.

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# DISINFECTION BY-PRODUCT COMPOUNDS REPORT

Client Name: STL Seattle
5755 8th St E
Tacoma, WA 98424

Reference Number: 05-04641

Project: 127528

| | | | |
|---|---|---|---|
| System Name: | | Field ID: | Source - 042605 |
| System ID Number: | | Lab Number: | 04610892 |
| DOH Source Number: | | Date Collected: | 4/26/2005 |
| Multiple Sources: | | Date Extracted: | 552_050502 |
| Sample Type: | | Date Analyzed: | 5/6/2005 |
| Sample Purpose: | Investigative or Other | Report Date: | 5/13/2005 |
| Sample Location: | Source - 042605 | Analyst: | CMH |
| County: | | Supervisor: | |

## EPA Method 552.2

| DOH# | COMPOUNDS | **RESULTS** | Units | SRL | Trigger | MCL | COMMENT |
|---|---|---|---|---|---|---|---|
| | **Halo-Acetic Acids** | | | | | | |
| | MONOCHLOROACETIC ACID | ND | ug/L | 2 | | | |
| | DICHLOROACETIC ACID | 3.8 | ug/L | 1 | | | |
| | TRICHLOROACETIC ACID | 1.7 | ug/L | 1 | | | |
| | MONOBROMOACETIC ACID | ND | ug/L | 1 | | | |
| | DIBROMOACETIC ACID | 2.7 | ug/L | 1 | | | |
| | HAA(5) | 8.2 | ug/L | 1 | 48 | 60 | |
| | **Other** | | | | | | |
| | BROMOCHLOROACETIC ACID | 2.4 | ug/L | 1 | | | |

A Result of "ND" indicates that the compound was not detected above the Lab's Method Detection Limit - MDL.
Maximum Contaminant Level, maximum permissible level of a contaminant in water established by EPA, NPDWR. State Advisory Level (SAL) for Unregulated compounds.
A blank MCL or SAL value indicates a level is not currently established.
If a compound is detected > or = to the State Reporting Level, SRL, specified increased monitoring frequencies may occur per DOH.
Method Detection Limit is the lab's minimum concentration a compound can be measured and reported with 99% confidence that the compound concentration is greater than zero.
J - Estimated value.

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# QUALITY CONTROL REPORT
# BLANK REPORT

Reference Number: 05-04641
Report Date: 05/13/05

| Batch | Analyte | Result | Units | Limit | QC Qualifier | Method | Type* | Comments |
|---|---|---|---|---|---|---|---|---|
| 552_050502 | MONOCHLOROACETIC ACID | ND | ug/L | 0.50 | | 552.2 | MB | |
| | DICHLOROACETIC ACID | ND | ug/L | 0.25 | | 552.2 | MB | |
| | TRICHLOROACETIC ACID | ND | ug/L | 0.25 | | 552.2 | MB | |
| | MONOBROMOACETIC ACID | ND | ug/L | 0.25 | | 552.2 | MB | |
| | DIBROMOACETIC ACID | ND | ug/L | 0.25 | | 552.2 | MB | |
| | BROMOCHLOROACETIC ACID | ND | ug/L | 0.25 | | 552.2 | MB | |
| | 2-BROMOPROPIONIC ACID (SURR) | 83 | % | 0.00 | | 552.2 | MB | |

---

*Notation:

LRB: Laboratory Reagent Blanks are used to determine the background level of the analytes in a laboratory batch. Therefore, this report may include analytes not requested for your submitted samples.

MB: Method Blanks are used to determine background levels of analytes in digested and extracted laboratory reagent water.

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Burlington, WA 98233
(800) 755-9295
(360) 757-1400 - FAX (360) 757-1402

# QUALITY CONTROL REPORT
## QCS/LFB REPORT

Reference Number: 05-04641
Report Date: 05/13/05

| Batch | Analyte | Result | True Value | Units | Method | % Recovery | Limits | QC Qualifier | Type* | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| 552_050502 | MONOCHLOROACETIC ACID | 17.3 | 15 | ug/L | 552.2 | 115 | 70-130 | | LFB | |
| | DICHLOROACETIC ACID | 13.7 | 15 | ug/L | 552.2 | 91 | 70-130 | | LFB | |
| | TRICHLOROACETIC ACID | 4.6 | 5 | ug/L | 552.2 | 92 | 70-130 | | LFB | |
| | MONOBROMOACETIC ACID | 10.6 | 10 | ug/L | 552.2 | 106 | 70-130 | | LFB | |
| | DIBROMOACETIC ACID | 4.8 | 5 | ug/L | 552.2 | 96 | 70-130 | | LFB | |
| | BROMOCHLOROACETIC ACID | 9.0 | 10 | ug/L | 552.2 | 90 | 70-130 | | LFB | |
| | 2-BROMOPROPIONIC ACID (SURR) | 84 | | % | 552.2 | NA | 70-130 | | LFB | |

---

*Notation:

% Recovery = (Result of Analysis)/(True Value) * 100

NA = Indicates % Recovery could not be calculated.

QCS: Quality Control Sample, a solution containing known concentrations of method analytes which is used to fortify an aliquot of reagent matrix. The QCS is obtained from an external source and is used to check lab performance.

LFB: Laboratory Fortified Blank, an aliquot of reagent matrix to which known quantities of method analytes are added in the lab. The LFB is analyzed exactly like a sample, and its purpose is to determine whether method performance is within accepted control limits.

EDGE ANALYTICAL
The lab you can trust!™

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# QUALITY CONTROL REPORT

## Duplicate and Matrix Spike/Matrix Spike Duplicate Report

Reference Number: 05-04641
Report Date: 5/13/2005

## Matrix Spike

| Batch | Sample | Analyte | Result | Spike Result | Duplicate Spike Result | Spike Conc | Units | Percent Recovery MS | Percent Recovery MSD | Limits | %RPD | Limits | QC Qualifier | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **552_050502** | | | | | | | | | | | | | | |
| | 3419 | MONOCHLOROACETIC ACID | | 19.4 | | 15 | ug/L | **129** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 3419 | DICHLOROACETIC ACID | 9.9 | 24.3 | | 15 | ug/L | **96** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 3419 | MONOBROMOACETIC ACID | | 10.2 | | 10 | ug/L | **102** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 3419 | DIBROMOACETIC ACID | | 5.7 | | 5 | ug/L | **114** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 3419 | BROMOCHLOROACETIC ACID | | 11.2 | | 10 | ug/L | **112** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 3419 | 2-BROMOPROPIONIC ACID (SURR) | 89 | 90 | | | % | | **NA** | 70-130 | **NA** | 0-50 | LFM | |
| | 10233 | MONOCHLOROACETIC ACID | | 17.1 | | 15 | ug/L | **114** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 10233 | DICHLOROACETIC ACID | 8.7 | 20.6 | | 15 | ug/L | **79** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 10233 | TRICHLOROACETIC ACID | 13.9 | 17.6 | | 5 | ug/L | **74** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 10233 | MONOBROMOACETIC ACID | | 9.3 | | 10 | ug/L | **93** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 10233 | DIBROMOACETIC ACID | | 4.8 | | 5 | ug/L | **96** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 10233 | BROMOCHLOROACETIC ACID | | 9.7 | | 10 | ug/L | **97** | **NA** | 70-130 | **NA** | 0-60 | LFM | |
| | 10233 | 2-BROMOPROPIONIC ACID (SURR) | 86 | 80 | | | % | | **NA** | 70-130 | **NA** | 0-50 | LFM | |

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%RPD = Relative Percent Difference

NA = Indicates %RPD could not be calculated

Matrix Spike (MS)/Matrix Spike Duplicate (MSD) analyses are used to determine the accuracy (MS) and precision (MSD) of a analytical method in a given sample matrix. Therefore, the usefulness of this report is limited to samples of similar matrices analyzed in the same analytical batch.

Only Duplicate sample with detections are listed in this report

# Chain of Custody Record

STL Seattle
5755 8th Street E.
Tacoma, WA 98424
Tel. 253-922-2310
Fax 253-922-5047
www.stl-inc.com

SEVERN TRENT **STL**

| | | | |
|---|---|---|---|
| Client: Stl-Seattle | Project Manager: Katie Downe | Date: 4/27/05 | Chain of Custody Number: 01013 |
| Address: | Telephone Number (Area Code)/Fax Number: | Lab Number: | Page 1 of 1 |
| City: / State: / Zip Code: | Site Contact: / Lab Contact: | | |
| Project Name and Location (State): 127528 | Carrier/Waybill Number: | | |
| Contract/Purchase Order/Quote No.: Will Call w/ P.O.# | | | |

Analysis (Attach list if more space is needed)

| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Matrix: Air | Aqueous | Sed. | Soil | | Containers & Preservatives: Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/ NaOH | | Halo acetic Acids | Special Instructions/ Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brinkley-E01 | 4/26/05 | 1110 | | X | | | | 1 | | | | | | | X | |
| Source-042605 | 4/26/05 | 1240 | | X | | | | 1 | | | | | | | X | |

Note: Samples are NOW Preserved

Cooler: ☐ Yes ☐ No Cooler Temp: ______

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days): ☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☒ Other 5/10

QC Requirements (Specify):

| | | | | | |
|---|---|---|---|---|---|
| 1. Relinquished By: Khes | Date: 4/27/05 | Time: 1300 | 1. Received By: C DeVeiteo | Date: 4/28/05 | Time: 10:00 |
| 2. Relinquished By: | Date: | Time: | 2. Received By: | Date: | Time: |
| 3. Relinquished By: | Date: | Time: | 3. Received By: | Date: | Time: |

Comments:

05-4641
10891-10892

**DISTRIBUTION:** WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy

STL8274-580 (12/02)

SEVERN TRENT STL

**STL Seattle**
5755 8th Street East
Tacoma, WA 98424

Tel: 253 922 2310
Fax: 253 922 5047
www.stl-inc.com

## TRANSMITTAL MEMORANDUM

DATE: May 12, 2005

TO: Steve Germiat
Aspect Consulting LLC
811 First Avenue, Suite 480
Seattle, WA 98104

PROJECT: Kennewick ASR

REPORT NUMBER: 127589

TOTAL NUMBER OF PAGES: ______

Enclosed are the test results for three samples received at STL Seattle on April 29, 2005.

The report consists of this transmittal memo, analytical results, quality control reports, a copy of the chain-of-custody, a list of data qualifiers and analytical narrative when applicable, and a copy of any requested raw data.

Should there be any questions regarding this report, please contact me at (253) 922-2310.

Sincerely,

Katie Downie
Project Manager

---

STL Seattle is a part of Severn Trent Laboratories, Inc.

# STL Seattle

Sample Identification:

| Lab. No. | Client ID | Date/Time Sampled | Matrix |
|---|---|---|---|
| 127589-1 | Thompson1-15G01 | 04-26-05 17:40 | Liquid |
| 127589-2 | Gilliam-17H01 | 04-27-05 12:20 | Liquid |
| 127589-3 | True-23D01 | 04-27-05 17:45 | Liquid |

# STL Seattle

| | |
|---|---|
| **Client Name** | Aspect Consulting LLC |
| **Project Name** | Kennewick ASR |
| **Date Received** | 04-29-05 |

General Chemistry Parameters

| | |
|---|---|
| **Client Sample ID** | Thompson1-15G01 |
| **Lab ID** | 127589-01 |

| Parameter | Method | Date Analyzed | Units | Result | PQL |
|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 174 | 5 |
| Bicarbonate (as CaCO3) | SM 2320B | 05-10-05 | mg/L | 174 | 5 |
| Total Dissolved Solids | SM 2540C | 05-03-04 | mg/L | 414 | 10 |

| | |
|---|---|
| **Client Sample ID** | Gilliam-17H01 |
| **Lab ID** | 127589-02 |

| Parameter | Method | Date Analyzed | Units | Result | PQL |
|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 168 | 5 |
| Bicarbonate (as CaCO3) | SM 2320B | 05-10-05 | mg/L | 168 | 5 |
| Total Dissolved Solids | SM 2540C | 05-03-04 | mg/L | 310 | 10 |

| | |
|---|---|
| **Client Sample ID** | True-23D01 |
| **Lab ID** | 127589-03 |

| Parameter | Method | Date Analyzed | Units | Result | PQL |
|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 156 | 5 |
| Bicarbonate (as CaCO3) | SM 2320B | 05-10-05 | mg/L | 156 | 5 |
| Total Dissolved Solids | SM 2540C | 05-03-04 | mg/L | 330 | 10 |

# STL Seattle

|  |  |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | THOMPSON1-15G01 |
| Lab ID: | 127589-01 |
| Date Received: | 4/29/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

### Metals by ICP - USEPA Method 200.7

| **Analyte** | | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|---|
| Calcium | | 60.2 | 1 | |
| Iron | ND | | 0.1 | |
| Magnesium | | 25.9 | 1 | |
| Manganese | ND | | 0.02 | |
| Potassium | | 7.36 | 3 | |
| Sodium | | 27.2 | 1 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | GILLIAM-17H01 |
| Lab ID: | 127589-02 |
| Date Received: | 4/29/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

**Metals by ICP - USEPA Method 200.7**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Calcium | 11.7 | 1 | |
| Iron | 0.605 | 0.1 | |
| Magnesium | 6.21 | 1 | |
| Manganese | ND | 0.02 | |
| Potassium | 10.6 | 3 | |
| Sodium | 71.2 | 1 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | TRUE-23D01 |
| Lab ID: | 127589-03 |
| Date Received: | 4/29/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

## Metals by ICP - USEPA Method 200.7

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Calcium | 19.8 | 1 | |
| Iron | 0.25 | 0.1 | |
| Magnesium | 10.2 | 1 | |
| Manganese | 0.0461 | 0.02 | |
| Potassium | 15.7 | 3 | |
| Sodium | 54.4 | 1 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | THOMPSON1-15G01 |
| Lab ID: | 127589-01 |
| Date Received: | 4/29/2005 |
| Date Prepared: | 5/2/2005 |
| Date Analyzed: | 5/2/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Anions by USEPA Method 300A**

| **Analyte** | **Result (mg/L)** | **PQL** | **MRL** | **Flags** |
|---|---|---|---|---|
| Chloride | 26 | 0.3 | 0.15 | |
| Sulfate | 82.2 | 1.5 | 0.75 | D5 |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | GILLIAM-17H01 |
| Lab ID: | 127589-02 |
| Date Received: | 4/29/2005 |
| Date Prepared: | 5/2/2005 |
| Date Analyzed: | 5/2/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Anions by USEPA Method 300A

| **Analyte** | **Result (mg/L)** | **PQL** | **MRL** | **Flags** |
|---|---|---|---|---|
| Chloride | 8.54 | 0.3 | 0.15 | |
| Sulfate | 27.4 | 0.3 | 0.15 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | TRUE-23D01 |
| Lab ID: | 127589-03 |
| Date Received: | 4/29/2005 |
| Date Prepared: | 5/2/2005 |
| Date Analyzed: | 5/2/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Anions by USEPA Method 300A

| Analyte | Result (mg/L) | PQL | MRL | Flags |
|---|---|---|---|---|
| Chloride | 10.7 | 0.3 | 0.15 | |
| Sulfate | 44.6 | 0.3 | 0.15 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Batch QC |
| Lab ID: | 127536-1 |
| QC Batch Number: | 1338-7 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Total Dissolved Solids | ND | 10 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Total Dissolved Solids | 262 | 248 | 5.65 | |

# STL Seattle

## QUALITY CONTROL REPORT

|  |  |
|---|---|
| Client Sample ID: | Batch QC |
| Lab ID: | 127528-1 |
| QC Batch Number: | 1343-1 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Bicarbonate (as CaCO3) | ND | 3 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Bicarbonate (as CaCO3) | 148 | 147 | 0.7 |  |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Batch QC |
| Lab ID: | 127528-1 |
| QC Batch Number: | 1343-1 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Alkalinity (as CaCO3) | ND | 3 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Alkalinity (as CaCO3) | 148 | 147 | 0.7 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - TP1181 |
| Date Received: | - |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

**Metals by ICP - USEPA Method 200.7**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Calcium | ND | 1 | |
| Iron | ND | 0.1 | |
| Magnesium | ND | 1 | |
| Manganese | ND | 0.02 | |
| Potassium | ND | 3 | |
| Sodium | ND | 1 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | EQUIPMENT RINSE |
| Lab ID: | 127553-04 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| QC Batch ID: | TP1181 |

Metals by ICP - USEPA Method 200.7

| **Parameter Name** | **Sample Result (mg/L)** | **Spike Amount (mg/L)** | **MS Result (mg/L)** | **MS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Calcium | 0 | 20 | 20.4 | 102 | |
| Iron | 0 | 22 | 22.5 | 102 | |
| Magnesium | 0 | 20 | 20.3 | 101 | |
| Manganese | 0 | 1 | 1.08 | 108 | |
| Potassium | 0 | 20 | 19.5 | 98 | |
| Sodium | 1.76 | 20 | 24.1 | 112 | |

# STL Seattle

## Duplicate Report

|  |  |
|---|---|
| Client Sample ID: | EQUIPMENT RINSE |
| Lab ID: | 127553-04 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| QC Batch ID: | TP1181 |

Metals by ICP - USEPA Method 200.7

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| Calcium | 0 | 0 | NC | |
| Iron | 0 | 0 | NC | |
| Magnesium | 0 | 0 | NC | |
| Manganese | 0 | 0 | NC | |
| Potassium | 0 | 0 | NC | |
| Sodium | 1.8 | 2 | -11.0 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - 2258 |
| Date Received: | - |
| Date Prepared: | 5/2/2005 |
| Date Analyzed: | 5/2/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Anions by USEPA Method 300A

| **Analyte** | **Result (mg/L)** | **PQL** | **MRL** | **Flags** |
|---|---|---|---|---|
| Chloride | ND | 0.3 | 0.15 | |
| Sulfate | ND | 0.3 | 0.15 | |

# STL Seattle

## Blank Spike Report

| | |
|---|---|
| Lab ID: | 2258 |
| Date Prepared: | 5/2/2005 |
| Date Analyzed: | 5/2/2005 |
| QC Batch ID: | 2258 |

Anions by USEPA Method 300A

| **Compound Name** | **Blank Result (mg/L)** | **Spike Amount (mg/L)** | **BS Result (mg/L)** | **BS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Chloride | 0 | 10 | 9.96 | 99.6 | |
| Sulfate | 0 | 10 | 9.65 | 96.5 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | NORTH POND |
| Lab ID: | 127605-01 |
| Date Prepared: | 5/2/2005 |
| Date Analyzed: | 5/2/2005 |
| QC Batch ID: | 2258 |

Anions by USEPA Method 300A

| **Compound Name** | **Sample Result (mg/L)** | **Spike Amount (mg/L)** | **MS Result (mg/L)** | **MS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Chloride | 2.2 | 40 | 41.6 | 98.7 | |
| Sulfate | 26 | 40 | 63.5 | 93.1 | |

# STL Seattle

## Duplicate Report

Client Sample ID: NORTH POND
Lab ID: 127605-01
Date Prepared: 5/2/2005
Date Analyzed: 5/2/2005
QC Batch ID: 2258

### Anions by USEPA Method 300A

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| Chloride | 2.18 | 2.17 | 0.5 | |
| Sulfate | 26.2 | 26.2 | 0.0 | |

SEVERN TRENT STL

STL Seattle
5755 8th Street East
Tacoma, WA 98424

Tel: 253 922 2310
Fax: 253 922 5047
www.stl-inc.com

## DATA QUALIFIERS AND ABBREVIATIONS

B1: This analyte was detected in the associated method blank. The analyte concentration was determined not to be significantly higher than the associated method blank (less than ten times the concentration reported in the blank).

B2: This analyte was detected in the associated method blank. The analyte concentration in the sample was determined to be significantly higher than the method blank (greater than ten times the concentration reported in the blank).

C1: Second column confirmation was performed. The relative percent difference value (RPD) between the results on the two columns was evaluated and determined to be < 40%.

C2: Second column confirmation was performed. The RPD between the results on the two columns was evaluated and determined to be > 40%. The higher result was reported unless anomalies were noted.

C3: Second analysis confirmation was performed. The relative percent difference value (RPD) between the results on the two columns was evaluated and determined to be ≤ 30%.

C4: Second analysis confirmation was performed. The RPD between the results on the two columns was evaluated and determined to be > 30%. The original analysis was reported unless anomalies were noted.

M: GC/MS confirmation was performed. The result derived from the original analysis was reported.

D: The reported result for this analyte was calculated based on a secondary dilution factor.

E: The concentration of this analyte exceeded the instrument calibration range and should be considered an estimated quantity.

J: The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

MCL: Maximum Contaminant Level

MDL: Method Detection Limit

RL: Reporting Limit

N: See analytical narrative

ND: Not Detected

X1: Contaminant does not appear to be "typical" product. Elution pattern suggests it may be __________.

X2: Contaminant does not appear to be "typical" product.

X3: Identification and quantitation of the analyte or surrogate was complicated by matrix interference.

X4: RPD for duplicates was outside advisory QC limits. The sample was re-analyzed with similar results. The sample matrix may be nonhomogeneous.

X4a: RPD for duplicates outside advisory QC limits due to analyte concentration near the method practical quantitation limit/detection limit.

X5: Matrix spike recovery was not determined due to the required dilution.

X6: Recovery and/or RPD values for matrix spike(/matrix spike duplicate) outside advisory QC limits. Sample was re-analyzed with similar results.

X7: Recovery and/or RPD values for matrix spike(/matrix spike duplicate) outside advisory QC limits. Matrix interference may be indicated based on acceptable blank spike recovery and/or RPD.

X7a: Recovery and/or RPD values for this spiked analyte outside advisory QC limits due to high concentration of the analyte in the original sample.

X8: Surrogate recovery was not determined due to the required dilution.

X9: Surrogate recovery outside advisory QC limits due to matrix interference.

# Chain of Custody Record

STL Seattle
5755 8th Street E.
Tacoma, WA 98424
Tel. 253-922-2310
Fax 253-922-5047
www.stl-inc.com

SEVERN TRENT STL

Client: Aspect Consulting
Project Manager: Steve Germiat
Date: 4/27/05
Chain of Custody Number: 19033
Address: 811 First Avenue, Suite 480
Telephone Number (Area Code)/Fax Number: (206) 838-5830
Lab Number: 27589
Page 1 of 1
City: Seattle
State: WA
Zip Code: 98104
Site Contact:
Lab Contact:
Project Name and Location (State): Kennewick ASR
Carrier/Waybill Number:
Contract/Purchase Order/Quote No.:

Analysis (Attach list if more space is needed): A B C D ICP

| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Matrix: Air | Aqueous | Sed. | Soil | Containers & Preservatives: Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/NaOH | EPA 310.1 Alkalinity | EPA 310.1 HCO3 | EPA 6010 Cations | EPA 300 Anions | EPA 6010 Metals | EPA 160.1 TDS | Special Instructions/ Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thompson 1 - 15G01 | 4/26/05 | 17:40 | | X | | | X | | X | | | | X | X | X | X | X | X | 3 Bottles |
| Gilliam - 17H01 | 4/27/05 | 12:20 | | X | | | X | | X | | | | X | X | X | X | X | X | 3 Bottles |
| True - 23D01 | 4/27/05 | 17:45 | | X | | | X | | X | | | | X | X | X | X | X | X | 3 Bottles |

* See attached "Partial List" for analysis descriptions.

Cooler ☐ Yes ☐ No Cooler Temp: ______

Possible Hazard Identification ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal ☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days) ☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☐ Other ______

QC Requirements (Specify)

| | Date | Time | | Date | Time |
|---|---|---|---|---|---|
| 1. Relinquished By | 4/28/05 | 11:10 | 1. Received By | 4/29/05 | 10A |
| 2. Relinquished By | | | 2. Received By | | |
| 3. Relinquished By | | | 3. Received By | | |

Comments

**DISTRIBUTION:** WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy

STL8274-580 (12/02)

SEVERN TRENT STL

**STL Seattle**
5755 8th Street East
Tacoma, WA 98424

Tel: 253 922 2310
Fax: 253 922 5047
www.stl-inc.com

# TRANSMITTAL MEMORANDUM

DATE: May 11, 2005

TO: Steve Germiat
Aspect Consulting LLC
811 First Avenue, Suite 480
Seattle, WA 98104

PROJECT: Kennewick ASR

REPORT NUMBER: 127528

TOTAL NUMBER OF PAGES: ______

Enclosed are the test results for two samples received at STL Seattle on April 27, 2005. The results for the haloacetic acid analyses and the radioactivity analyses will be submitted at a later date.

The report consists of this transmittal memo, analytical results, quality control reports, a copy of the chain-of-custody, a list of data qualifiers and analytical narrative when applicable, and a copy of any requested raw data.

Should there be any questions regarding this report, please contact me at (253) 922-2310.

Sincerely,

Katie Downie

Katie Downie
Project Manager

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STL Seattle is a part of Severn Trent Laboratories, Inc.

# STL Seattle

Sample Identification:

| Lab. No. | Client ID | Date/Time Sampled | Matrix |
|---|---|---|---|
| 127528-1 | Brinkley -E01 | 04-26-05 11:10 | Liquid |
| 127528-2 | Source-042605 | 04-26-05 12:40 | Liquid |

# STL Seattle

|  |  |
|---|---|
| **Client Name** | Aspect Consulting LLC |
| **Project Name** | Kennewick ASR |
| **Date Received** | 04-27-05 |

General Chemistry Parameters

|  |  |
|---|---|
| **Client Sample ID** | Brinkley -E01 |
| **Lab ID** | 127528-01 |

| **Parameter** | **Method** | **Date Analyzed** | **Units** | **Result** | **PQL** |
|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 148 | 5 |
| Ammonia Nitrogen | EPA 350.1 | 04-28-05 | mg/L | ND | 0.04 |
| Bicarbonate (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 148 | 5 |
| Color | EPA 110.2 | 04-27-05 | color | 10 | 5 |
| Cyanide | EPA 335.3 | 05-05-05 | mg/L | ND | 20 |
| Total Dissolved Solids | SM 2540C | 05-03-05 | mg/L | 341 | 10 |
| Total Suspended Solids | EPA 160.2 | 05-02-05 | mg/L | ND | 4 |

|  |  |
|---|---|
| **Client Sample ID** | Source-042605 |
| **Lab ID** | 127528-02 |

| **Parameter** | **Method** | **Date Analyzed** | **Units** | **Result** | **PQL** |
|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 165 | 5 |
| Ammonia Nitrogen | EPA 350.1 | 04-28-05 | mg/L | ND | 0.04 |
| Bicarbonate (as CaCO3) | EPA 310.1 | 05-10-05 | mg/L | 165 | 5 |
| Color | EPA 110.2 | 04-27-05 | color | 10 | 5 |
| Cyanide | EPA 335.3 | 05-05-05 | mg/L | ND | 20 |
| Total Dissolved Solids | SM 2540C | 05-03-05 | mg/L | 291 | 10 |
| Total Suspended Solids | EPA 160.2 | 05-02-05 | mg/L | ND | 4 |

# STL Seattle

| | |
|---|---|
| Client Name: | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Volatile Organics by EPA Method 524.2

| | | | Recovery Limits | |
|---|---|---|---|---|
| **Surrogate** | **% Recovery** | **Flags** | **Low** | **High** |
| Dibromofluoromethane | 90.7 | | 74.5 | 118 |
| Fluorobenzene | 99.2 | | 75 | 120 |
| Toluene-D8 | 100 | | 78 | 123 |
| Ethylbenzene-d10 | 101 | | 77 | 126 |
| Bromofluorobenzene | 96 | | 72 | 120 |
| Trifluorotoluene | 111 | | 74 | 126 |

| **Analyte** | **Result (ug/L)** | **RL** | **Flags** |
|---|---|---|---|
| Chloroform | ND | 0.5 | |
| Bromodichloromethane | ND | 0.5 | |
| Dibromochloromethane | ND | 0.5 | |
| Bromoform | ND | 0.5 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Tentatively Identified Compounds - USEPA Method 524.2 Modified**

| TIC Name | Result (ug/L) | Ret. Time (Min.) | Flags |
|---|---|---|---|
| No TIC's Found | | | |

# STL Seattle

| | |
|---|---|
| Client Name: | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Volatile Organics by EPA Method 524.2

| **Surrogate** | **% Recovery** | **Flags** | **Recovery Limits**<br>**Low** | <br>**High** |
|---|---|---|---|---|
| Dibromofluoromethane | 86.7 | | 74.5 | 118 |
| Fluorobenzene | 99.4 | | 75 | 120 |
| Toluene-D8 | 96.8 | | 78 | 123 |
| Ethylbenzene-d10 | 99.5 | | 77 | 126 |
| Bromofluorobenzene | 95.6 | | 72 | 120 |
| Trifluorotoluene | 109 | | 74 | 126 |

| **Analyte** | **Result (ug/L)** | **RL** | **Flags** |
|---|---|---|---|
| Chloroform | 5.06 | 0.5 | C3 |
| Bromodichloromethane | 5.68 | 0.5 | C3 |
| Dibromochloromethane | 6.87 | 0.5 | C3 |
| Bromoform | 2.56 | 0.5 | C3 |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Tentatively Identified Compounds - USEPA Method 524.2 Modified**

| **TIC Name** | **Result (ug/L)** | **Ret. Time (Min.)** | **Flags** |
|---|---|---|---|
| No TIC's Found | | | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 5 |

**Metals by ICP-MS - USEPA Method 200.8**

| Analyte | Result (mg/L) | RL | Flags |
|---|---|---|---|
| Arsenic | 0.00259 | 0.001 | |
| Antimony | 0.00118 | 0.001 | |
| Lead | 0.00178 | 0.001 | |
| Selenium | 0.0015 | 0.001 | |
| Thallium | ND | 0.001 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

## Metals by ICP - USEPA Method 200.7

| Analyte | Result (mg/L) | | RL | Flags |
|---|---|---|---|---|
| Aluminum | ND | | 0.1 | |
| Barium | | 0.023 | 0.005 | |
| Beryllium | ND | | 0.005 | |
| Cadmium | ND | | 0.005 | |
| Calcium | | 43.3 | 1 | |
| Chromium | ND | | 0.02 | |
| Copper | | 0.0529 | 0.02 | |
| Iron | ND | | 0.1 | |
| Magnesium | | 21.1 | 1 | |
| Manganese | ND | | 0.02 | |
| Nickel | ND | | 0.02 | |
| Potassium | ND | | 3 | |
| Selenium | ND | | 0.1 | |
| Silver | ND | | 0.01 | |
| Sodium | | 27.2 | 1 | |
| Silica | | 103 | 1.07 | |
| Zinc | | 0.154 | 0.015 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/05 |
| Date Prepared: | 5/6/05 |
| Date Analyzed: | 5/6/05 |
| Dilution Factor | 1 |

**Mercury by CVAA - USEPA Method 245.1**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Mercury | ND | 0.0002 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 5 |

**Metals by ICP-MS - USEPA Method 200.8**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Arsenic | ND | 0.001 | |
| Antimony | ND | 0.001 | |
| Lead | ND | 0.001 | |
| Selenium | ND | 0.001 | |
| Thallium | ND | 0.001 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/05 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

**Metals by ICP - USEPA Method 200.7**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Aluminum | ND | 0.1 | |
| Barium | 0.0581 | 0.005 | |
| Beryllium | ND | 0.005 | |
| Cadmium | ND | 0.005 | |
| Calcium | 47.3 | 1 | |
| Chromium | ND | 0.02 | |
| Copper | ND | 0.02 | |
| Iron | ND | 0.1 | |
| Magnesium | 16.6 | 1 | |
| Manganese | ND | 0.02 | |
| Nickel | ND | 0.02 | |
| Potassium | 3.83 | 3 | |
| Selenium | ND | 0.1 | |
| Silver | ND | 0.01 | |
| Sodium | 24 | 1 | |
| Silica | 27.6 | 1.07 | |
| Zinc | ND | 0.015 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/05 |
| Date Prepared: | 5/6/05 |
| Date Analyzed: | 5/6/05 |
| Dilution Factor | 1 |

**Mercury by CVAA - USEPA Method 245.1**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Mercury | ND | 0.0002 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Anions by USEPA Method 300A

| Analyte | Result (mg/L) | PQL | MRL | Flags |
|---|---|---|---|---|
| Fluoride | 0.415 | 0.06 | 0.03 | |
| Chloride | 21.1 | 0.3 | 0.15 | |
| Nitrite | ND | 0.031 | 0.015 | |
| Bromide | 0.117 | 0.1 | 0.05 | |
| Nitrate | 2.64 | 0.03 | 0.015 | |
| Sulfate | 51.4 | 1.5 | 0.75 | D5 |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Anions by USEPA Method 300A**

| **Analyte** | | **Result (mg/L)** | **PQL** | **MRL** | **Flags** |
|---|---|---|---|---|---|
| Fluoride | | 0.176 | 0.06 | 0.03 | |
| Chloride | | 16.6 | 0.3 | 0.15 | |
| Nitrite | ND | | 0.031 | 0.015 | |
| Bromide | ND | | 0.1 | 0.05 | |
| Nitrate | | 2.93 | 0.03 | 0.015 | |
| Sulfate | | 31.8 | 0.3 | 0.15 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Total Organic Carbon by USEPA Method 415.1**

| Analyte | Result (mg/L) | RL | Flags |
|---|---|---|---|
| TOC | 2.54 | 1 | |

# STL Seattle

| | |
|---|---|
| Client Name | Aspect Consulting LLC |
| Client ID: | SOURCE-042605 |
| Lab ID: | 127528-02 |
| Date Received: | 4/27/2005 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Total Organic Carbon by USEPA Method 415.1**

| Analyte | Result (mg/L) | RL | Flags |
|---|---|---|---|
| TOC | 2.42 | 1 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Source-042605 |
| Lab ID: | 127528-02 |
| QC Batch Number: | 1092-50 |

### Method Blank

| Parameter | Result (color) | PQL |
|---|---|---|
| Color | ND | 5 |

### Duplicate

| Parameter | Sample Result (color) | Duplicate Result (color) | RPD (%) | Flag |
|---|---|---|---|---|
| Color | 10 | 10 | 0.0 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Source-042605 |
| Lab ID: | 127528-02 |
| QC Batch Number: | R3604 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Ammonia Nitrogen | ND | 0.04 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Ammonia Nitrogen | ND | ND | NC | |

### Matrix Spike

| Parameter | Sample Result (mg/L) | Matrix Spike Result (mg/L) | Spike Amount (mg/L) | Recovery (%) | Flag |
|---|---|---|---|---|---|
| Ammonia Nitrogen | ND | 0.97 | 1.0 | 97 | |

# STL Seattle

## QUALITY CONTROL REPORT

Client Sample ID: Batch QC
Lab ID: 127538-1
QC Batch Number: 1338-5

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Total Suspended Solids | ND | 2 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Total Suspended Solids | 198 | 202 | 2 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Batch QC |
| Lab ID: | 127536-1 |
| QC Batch Number: | 1338-7 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Total Dissolved Solids | ND | 10 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Total Dissolved Solids | 262 | 248 | 5.65 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Brinkley -E01 |
| Lab ID: | 127528-01 |
| QC Batch Number: | 1271-120 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Cyanide | ND | 0.05 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Cyanide | ND | ND | NC | |

### Matrix Spike

| Parameter | Sample Result (mg/L) | Matrix Spike Result (mg/L) | Spike Amount (mg/L) | Recovery (%) | Flag |
|---|---|---|---|---|---|
| Cyanide | ND | 0.10 | 0.10 | 100 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Brinkley -E01 |
| Lab ID: | 127528-01 |
| QC Batch Number: | 1343-1 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Bicarbonate (as CaCO3) | ND | 3 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Bicarbonate (as CaCO3) | 148 | 147 | 0.7 | |

# STL Seattle

## QUALITY CONTROL REPORT

| | |
|---|---|
| Client Sample ID: | Brinkley -E01 |
| Lab ID: | 127528-01 |
| QC Batch Number: | 1343-1 |

### Method Blank

| Parameter | Result (mg/L) | PQL |
|---|---|---|
| Alkalinity (as CaCO3) | ND | 3 |

### Duplicate

| Parameter | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD (%) | Flag |
|---|---|---|---|---|
| Alkalinity (as CaCO3) | 148 | 147 | 0.7 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - VOA1271 |
| Date Received: | - |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Volatile Organics by EPA Method 524.2

| Surrogate | % Recovery | Flags | Recovery Limits Low | Recovery Limits High |
|---|---|---|---|---|
| Dibromofluoromethane | 89.1 | | 74.5 | 118 |
| Fluorobenzene | 100 | | 75 | 120 |
| Toluene-D8 | 97.9 | | 78 | 123 |
| Ethylbenzene-d10 | 101 | | 77 | 126 |
| Bromofluorobenzene | 96.6 | | 72 | 120 |
| Trifluorotoluene | 95.5 | | 74 | 126 |

| Analyte | Result (ug/L) | RL | Flags |
|---|---|---|---|
| Chloroform | ND | 0.5 | |
| Bromodichloromethane | ND | 0.5 | |
| Dibromochloromethane | ND | 0.5 | |
| Bromoform | ND | 0.5 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - VOA1271 |
| Date Received: | - |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | 1 |

**Tentatively Identified Compounds - USEPA Method 524.2 Modified**

| **TIC Name** | **Result (ug/L)** | **Ret. Time (Min.)** | **Flags** |
|---|---|---|---|
| No TIC's Found | | | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - TP1181 |
| Date Received: | - |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

**Metals by ICP-MS - USEPA Method 200.8**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Arsenic | ND | 0.0002 | |
| Antimony | ND | 0.0002 | |
| Lead | ND | 0.0002 | |
| Selenium | ND | 0.0002 | |
| Thallium | ND | 0.0002 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - TP1181 |
| Date Received: | - |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| Dilution Factor | 1 |

## Metals by ICP - USEPA Method 200.7

| Analyte | Result (mg/L) | RL | Flags |
|---|---|---|---|
| Aluminum | ND | 0.1 | |
| Barium | ND | 0.005 | |
| Beryllium | ND | 0.005 | |
| Cadmium | ND | 0.005 | |
| Calcium | ND | 1 | |
| Chromium | ND | 0.02 | |
| Copper | ND | 0.02 | |
| Iron | ND | 0.1 | |
| Magnesium | ND | 1 | |
| Manganese | ND | 0.02 | |
| Nickel | ND | 0.02 | |
| Potassium | ND | 3 | |
| Selenium | ND | 0.1 | |
| Silver | ND | 0.01 | |
| Sodium | ND | 1 | |
| Silica | ND | 1.07 | |
| Zinc | ND | 0.015 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - ZT335 |
| Date Received: | - |
| Date Prepared: | 5/6/05 |
| Date Analyzed: | 5/6/05 |
| Dilution Factor | 1 |

**Mercury by CVAA - USEPA Method 245.1**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| Mercury | ND | 0.0002 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | EQUIPMENT RINSE |
| Lab ID: | 127553-04 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| QC Batch ID: | TP1181 |

### Metals by ICP-MS - USEPA Method 200.8

| **Parameter Name** | **Sample Result (mg/L)** | **Spike Amount (mg/L)** | **MS Result (mg/L)** | **MS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Arsenic | 0 | 4 | 4.01 | 100 | |
| Antimony | 0 | 3 | 3.41 | 114 | |
| Lead | 0.00299 | 1 | 1.03 | 103 | |
| Selenium | 0 | 4 | 4.15 | 104 | |
| Thallium | 0 | 4 | 3.83 | 96 | |

# STL Seattle

## Matrix Spike Report

Client Sample ID: EQUIPMENT RINSE
Lab ID: 127553-04
Date Prepared: 5/2/05
Date Analyzed: 5/2/05
QC Batch ID: TP1181

### Metals by ICP - USEPA Method 200.7

| Parameter Name | Sample Result (mg/L) | Spike Amount (mg/L) | MS Result (mg/L) | MS % Rec. | Flag |
|---|---|---|---|---|---|
| Aluminum | 0 | 4 | 3.86 | 97 | |
| Barium | 0 | 4 | 3.96 | 99 | |
| Beryllium | 0 | 0.1 | 0.0983 | 98 | |
| Cadmium | 0 | 0.1 | 0.0973 | 97 | |
| Calcium | 0 | 20 | 20.4 | 102 | |
| Chromium | 0 | 0.4 | 0.377 | 94 | |
| Copper | 0 | 0.5 | 0.482 | 96 | |
| Iron | 0 | 22 | 22.5 | 102 | |
| Magnesium | 0 | 20 | 20.3 | 101 | |
| Manganese | 0 | 1 | 1.08 | 108 | |
| Nickel | 0 | 1 | 0.981 | 98 | |
| Potassium | 0 | 20 | 19.5 | 98 | |
| Selenium | 0 | 4 | 3.94 | 99 | |
| Silver | 0 | 0.6 | 0.564 | 94 | |
| Sodium | 1.76 | 20 | 24.1 | 112 | |
| Silica | 123 | 42.8 | 161 | 89 | |
| Zinc | 0 | 1 | 0.995 | 100 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | 4411-5W01 |
| Lab ID: | 127604-02 |
| Date Prepared: | 5/6/05 |
| Date Analyzed: | 5/6/05 |
| QC Batch ID: | ZT335 |

Mercury by CVAA - USEPA Method 245.1

| Parameter Name | Sample Result (mg/L) | Spike Amount (mg/L) | MS Result (mg/L) | MS % Rec. | Flag |
|---|---|---|---|---|---|
| Mercury | 0 | 0.002 | 0.00211 | 106 | |

# STL Seattle

## Duplicate Report

| | |
|---|---|
| Client Sample ID: | EQUIPMENT RINSE |
| Lab ID: | 127553-04 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| QC Batch ID: | TP1181 |

Metals by ICP-MS - USEPA Method 200.8

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| Arsenic | 0 | 0 | NC | |
| Antimony | 0 | 0 | NC | |
| Lead | 0.003 | 0.0014 | 73.0 | X4a |
| Selenium | 0 | 0 | NC | |
| Thallium | 0 | 0 | NC | |

# STL Seattle

## Duplicate Report

| | |
|---|---|
| Client Sample ID: | EQUIPMENT RINSE |
| Lab ID: | 127553-04 |
| Date Prepared: | 5/2/05 |
| Date Analyzed: | 5/2/05 |
| QC Batch ID: | TP1181 |

### Metals by ICP - USEPA Method 200.7

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| Aluminum | 0 | 0 | NC | |
| Barium | 0 | 0 | NC | |
| Beryllium | 0 | 0 | NC | |
| Cadmium | 0 | 0 | NC | |
| Calcium | 0 | 0 | NC | |
| Chromium | 0 | 0 | NC | |
| Copper | 0 | 0 | NC | |
| Iron | 0 | 0 | NC | |
| Magnesium | 0 | 0 | NC | |
| Manganese | 0 | 0 | NC | |
| Nickel | 0 | 0 | NC | |
| Potassium | 0 | 0 | NC | |
| Selenium | 0 | 0 | NC | |
| Silver | 0 | 0 | NC | |
| Sodium | 1.8 | 2 | -11.0 | |
| Silica | 120 | 120 | 0.0 | |
| Zinc | 0 | 0 | NC | |

# STL Seattle

## Duplicate Report

| | |
|---|---|
| Client Sample ID: | 4411-5W01 |
| Lab ID: | 127604-02 |
| Date Prepared: | 5/6/05 |
| Date Analyzed: | 5/6/05 |
| QC Batch ID: | ZT335 |

Mercury by CVAA - USEPA Method 245.1

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| Mercury | 0 | 0 | NC | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - 2256 |
| Date Received: | - |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Anions by USEPA Method 300A

| Analyte | Result (mg/L) | PQL | MRL | Flags |
|---|---|---|---|---|
| Fluoride | ND | 0.06 | 0.03 | |
| Chloride | ND | 0.3 | 0.15 | |
| Nitrite | ND | 0.031 | 0.015 | |
| Bromide | ND | 0.1 | 0.05 | |
| Nitrate | ND | 0.03 | 0.015 | |
| Sulfate | ND | 0.3 | 0.15 | |

# STL Seattle

## Blank Spike Report

| | |
|---|---|
| Lab ID: | 2256 |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| QC Batch ID: | 2256 |

### Anions by USEPA Method 300A

| **Compound Name** | **Blank Result (mg/L)** | **Spike Amount (mg/L)** | **BS Result (mg/L)** | **BS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Fluoride | 0 | 2 | 1.9 | 95 | |
| Chloride | 0 | 10 | 9.91 | 99.1 | |
| Nitrite | 0 | 1 | 0.934 | 93.4 | |
| Bromide | 0 | 1 | 0.939 | 93.9 | |
| Nitrate | 0 | 1 | 0.971 | 97.1 | |
| Sulfate | 0 | 10 | 9.53 | 95.3 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| QC Batch ID: | 2256 |

### Anions by USEPA Method 300A

| **Compound Name** | **Sample Result (mg/L)** | **Spike Amount (mg/L)** | **MS Result (mg/L)** | **MS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Fluoride | 0.42 | 8 | 7.99 | 94.7 | |
| Chloride | 21 | 40 | 57.1 | 89.8 | X7 |
| Nitrite | 0 | 2 | 1.91 | 95.4 | |
| Bromide | 0.12 | 4 | 3.96 | 96 | |
| Nitrate | 2.6 | 4 | 6.29 | 91.1 | |
| Sulfate | 51 | 40 | 92 | 102 | |

# STL Seattle

## Duplicate Report

Client Sample ID: BRINKLEY -E01
Lab ID: 127528-01
Date Prepared: 4/27/2005
Date Analyzed: 4/27/2005
QC Batch ID: 2256

Anions by USEPA Method 300A

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| Fluoride | 0.415 | 0.411 | 1.0 | |
| Chloride | 21.1 | 21 | 0.5 | |
| Nitrite | 0 | 0 | NC | |
| Bromide | 0.117 | 0.114 | 2.6 | |
| Nitrate | 2.64 | 2.64 | 0.0 | |
| Sulfate | 51.4 | 51.4 | 0.0 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - TOC1270 |
| Date Received: | - |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | **1** |

**Total Organic Carbon by USEPA Method 415.1**

| **Analyte** | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|
| TOC | ND | 1 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| QC Batch ID: | TOC1270 |

Total Organic Carbon by USEPA Method 415.1

| Compound Name | Sample Result (mg/L) | Spike Amount (mg/L) | MS Result (mg/L) | MS % Rec. | Flag |
|---|---|---|---|---|---|
| TOC | 2.5 | 10 | 12.8 | 102 | |

# STL Seattle

## Duplicate Report

| | |
|---|---|
| Client Sample ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| QC Batch ID: | TOC1270 |

Total Organic Carbon by USEPA Method 415.1

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| TOC | 2.54 | 2.45 | 3.6 | |

SEVERN TRENT STL

STL Seattle
5755 8th Street East
Tacoma, WA 98424

Tel: 253 922 2310
Fax: 253 922 5047
www.stl-inc.com

## DATA QUALIFIERS AND ABBREVIATIONS

| | |
|---|---|
| B1: | This analyte was detected in the associated method blank. The analyte concentration was determined not to be significantly higher than the associated method blank (less than ten times the concentration reported in the blank). |
| B2: | This analyte was detected in the associated method blank. The analyte concentration in the sample was determined to be significantly higher than the method blank (greater than ten times the concentration reported in the blank). |
| C1: | Second column confirmation was performed. The relative percent difference value (RPD) between the results on the two columns was evaluated and determined to be < 40%. |
| C2: | Second column confirmation was performed. The RPD between the results on the two columns was evaluated and determined to be > 40%. The higher result was reported unless anomalies were noted. |
| C3: | Second analysis confirmation was performed. The relative percent difference value (RPD) between the results on the two columns was evaluated and determined to be ≤ 30%. |
| C4: | Second analysis confirmation was performed. The RPD between the results on the two columns was evaluated and determined to be > 30%. The original analysis was reported unless anomalies were noted. |
| M: | GC/MS confirmation was performed. The result derived from the original analysis was reported. |
| D: | The reported result for this analyte was calculated based on a secondary dilution factor. |
| E: | The concentration of this analyte exceeded the instrument calibration range and should be considered an estimated quantity. |
| J: | The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity. |
| MCL: | Maximum Contaminant Level |
| MDL: | Method Detection Limit |
| RL: | Reporting Limit |
| N: | See analytical narrative |
| ND: | Not Detected |
| X1: | Contaminant does not appear to be "typical" product. Elution pattern suggests it may be __________. |
| X2: | Contaminant does not appear to be "typical" product. |
| X3: | Identification and quantitation of the analyte or surrogate was complicated by matrix interference. |
| X4: | RPD for duplicates was outside advisory QC limits. The sample was re-analyzed with similar results. The sample matrix may be nonhomogeneous. |
| X4a: | RPD for duplicates outside advisory QC limits due to analyte concentration near the method practical quantitation limit/detection limit. |
| X5: | Matrix spike recovery was not determined due to the required dilution. |
| X6: | Recovery and/or RPD values for matrix spike(/matrix spike duplicate) outside advisory QC limits. Sample was re-analyzed with similar results. |
| X7: | Recovery and/or RPD values for matrix spike(/matrix spike duplicate) outside advisory QC limits. Matrix interference may be indicated based on acceptable blank spike recovery and/or RPD. |
| X7a: | Recovery and/or RPD values for this spiked analyte outside advisory QC limits due to high concentration of the analyte in the original sample. |
| X8: | Surrogate recovery was not determined due to the required dilution. |
| X9: | Surrogate recovery outside advisory QC limits due to matrix interference. |

[redacted]

# Chain of Custody Record

**STL Seattle**
**5755 8th Street E.**
**Tacoma, WA 98424**
**Tel. 253-922-2310**
**Fax 253-922-5047**
**www.stl-inc.com**

SEVERN TRENT STL

Client: Aspect Consulting
Project Manager: Steve Germiat
Date: 4/26/05
Chain of Custody Number: 19032
Address: 811 First Ave, Suite 480
Telephone Number (Area Code)/Fax Number: (206) 838-5830
Lab Number: 127528
Page ____ of ____
City: Seattle
State: WA
Zip Code: 98104
Site Contact:
Lab Contact:
Project Name and Location (State): Kennewick ASR
Carrier/Waybill Number:
Contract/Purchase Order/Quote No.:

Analysis (Attach list if more space is needed)

| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Air | Aqueous | Sed. | Soil | | Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/NaOH | | EPA 310.1 Alkalinity | EPA 310.1 HCO3 | EPA 6010 Cations | EPA 300 Anions | EPA 6010 Metals ICP | EPA 6020 Metals by | EPA 7470 Mercury | EPA 6010 Silica | EPA 350.1 Ammonia | EPA 160.1 TDS | EPA 160.2 TSS | EPA 110.2 Color | EPA 415.1 TOC | EPA 524.2 Trihalomethanes | Special Instructions/ Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brinkley - E01 | 4/26/05 | 11:10 | | X | | | | X | X | X | X | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 8 Bottles - STL Seat |
| Source - 042605 | 4/26/05 | 12:40 | | X | | | | X | X | X | X | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 8 Bottles - STL Seatt |

* See attached - Full List

Cooler
☐ Yes ☐ No Cooler Temp: ______

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal
☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days)
☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☐ Other ______

QC Requirements (Specify)

| | Date | Time | | Date | Time |
|---|---|---|---|---|---|
| 1. Relinquished By | 4/26/05 | 15:15 | 1. Received By | 4/26/05 | 15:15 |
| 2. Relinquished By | 4/26/05 | 15:15 | 2. Received By | 4/27/05 | 0930 |
| 3. Relinquished By | | | 3. Received By | | |

Comments

**DISTRIBUTION:** WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy

STL8274-580 (12/02)

[redacted]

# Chain of Custody Record

STL Seattle
5755 8th Street E.
Tacoma, WA 98424
Tel. 253-922-2310
Fax 253-922-5047
www.stl-inc.com

SEVERN TRENT STL

Client: Aspect Consulting
Project Manager: Steve Germiat
Date: 4/26/05
Chain of Custody Number: 19039
Address: Colman Building, 811 First Ave Suite 480
Telephone Number (Area Code)/Fax Number: (206) 838-5830
Lab Number: 17528
Page ______ of ______
City: Seattle
State: WA
Zip Code: 98104
Site Contact:
Lab Contact:
Project Name and Location (State): Kennewick ASR
Carrier/Waybill Number:
Contract/Purchase Order/Quote No.:

Analysis (Attach list if more space is needed)

| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Matrix: Air | Aqueous | Sed. | Soil | | Containers & Preservatives: Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/NaOH | | EPA 524.2 | Haloacetic Acid | | | | | | | | | | | Special Instructions/Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brinkley - E01 | 4/26/05 | 12:10 | | X | | | | X | | | | | | | X | | | | 1 | Bottle | | | | | | | To Edge Analytical |
| Source - 042605 | 4/26/05 | 12:40 | | X | | | | X | | | | | | | X | | | | 1 | Bottle | | | | | | | " |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | X SEE attached - full list. | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Cooler: ☐ Yes ☐ No Cooler Temp: ______

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days): ☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☐ Other ______

QC Requirements (Specify)

| | Date | Time | | Date | Time |
|---|---|---|---|---|---|
| 1. Relinquished By | 4/26/05 | 15:15 | 1. Received By | 4/26/05 | 15:15 |
| 2. Relinquished By | 4/26/05 | 15:15 | 2. Received By | 4/27/05 | 0935 |
| 3. Relinquished By | | | 3. Received By | | |

Comments

DISTRIBUTION: WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - 2256 |
| Date Received: | - |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| % Solids | - |
| Dilution Factor | 1 |

## Anions by USEPA Method 300A

| Analyte | Result (mg/L) | PQL | MRL | Flags |
|---|---|---|---|---|
| Fluoride | ND | 0.06 | 0.03 | |
| Chloride | ND | 0.3 | 0.15 | |
| Nitrite | ND | 0.031 | 0.015 | |
| Bromide | ND | 0.1 | 0.05 | |
| Nitrate | ND | 0.03 | 0.015 | |
| Sulfate | ND | 0.3 | 0.15 | |

# STL Seattle

## Blank Spike Report

| | |
|---|---|
| Lab ID: | 2256 |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| QC Batch ID: | 2256 |

### Anions by USEPA Method 300A

| **Compound Name** | **Blank Result (mg/L)** | **Spike Amount (mg/L)** | **BS Result (mg/L)** | **BS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Fluoride | 0 | 2 | 1.9 | 95 | |
| Chloride | 0 | 10 | 9.91 | 99.1 | |
| Nitrite | 0 | 1 | 0.934 | 93.4 | |
| Bromide | 0 | 1 | 0.939 | 93.9 | |
| Nitrate | 0 | 1 | 0.971 | 97.1 | |
| Sulfate | 0 | 10 | 9.53 | 95.3 | |

# STL Seattle

## Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Prepared: | 4/27/2005 |
| Date Analyzed: | 4/27/2005 |
| QC Batch ID: | 2256 |

### Anions by USEPA Method 300A

| **Compound Name** | **Sample Result (mg/L)** | **Spike Amount (mg/L)** | **MS Result (mg/L)** | **MS % Rec.** | **Flag** |
|---|---|---|---|---|---|
| Fluoride | 0.42 | 8 | 7.99 | 94.7 | |
| Chloride | 21 | 40 | 57.1 | 89.8 | X7 |
| Nitrite | 0 | 2 | 1.91 | 95.4 | |
| Bromide | 0.12 | 4 | 3.96 | 96 | |
| Nitrate | 2.6 | 4 | 6.29 | 91.1 | |
| Sulfate | 51 | 40 | 92 | 102 | |

# STL Seattle

## Duplicate Report

Client Sample ID: BRINKLEY -E01
Lab ID: 127528-01
Date Prepared: 4/27/2005
Date Analyzed: 4/27/2005
QC Batch ID: 2256

Anions by USEPA Method 300A

| Parameter Name | Sample Result (mg/L) | Duplicate Result (mg/L) | RPD % | Flag |
|---|---|---|---|---|
| Fluoride | 0.415 | 0.411 | 1.0 | |
| Chloride | 21.1 | 21 | 0.5 | |
| Nitrite | 0 | 0 | NC | |
| Bromide | 0.117 | 0.114 | 2.6 | |
| Nitrate | 2.64 | 2.64 | 0.0 | |
| Sulfate | 51.4 | 51.4 | 0.0 | |

# STL Seattle

| | |
|---|---|
| Lab ID: | Method Blank - TOC1270 |
| Date Received: | - |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| % Solids | - |
| Dilution Factor | **1** |

**Total Organic Carbon by USEPA Method 415.1**

| **Analyte** | | **Result (mg/L)** | **RL** | **Flags** |
|---|---|---|---|---|
| TOC | ND | | 1 | |

# STL Seattle

Matrix Spike Report

| | |
|---|---|
| Client Sample ID: | BRINKLEY -E01 |
| Lab ID: | 127528-01 |
| Date Prepared: | 4/28/2005 |
| Date Analyzed: | 4/28/2005 |
| QC Batch ID: | TOC1270 |

Total Organic Carbon by USEPA Method 415.1

| Compound Name | Sample Result (mg/L) | Spike Amount (mg/L) | MS Result (mg/L) | MS % Rec. | Flag |
|---|---|---|---|---|---|
| TOC | 2.5 | 10 | 12.8 | 102 | |

# STL Seattle

## Duplicate Report

Client Sample ID: BRINKLEY -E01
Lab ID: 127528-01
Date Prepared: 4/28/2005
Date Analyzed: 4/28/2005
QC Batch ID: TOC1270

### Total Organic Carbon by USEPA Method 415.1

| **Parameter Name** | **Sample Result (mg/L)** | **Duplicate Result (mg/L)** | **RPD %** | **Flag** |
|---|---|---|---|---|
| TOC | 2.54 | 2.45 | 3.6 | |

SEVERN TRENT STL

STL Seattle
5755 8th Street East
Tacoma, WA 98424

Tel: 253 922 2310
Fax: 253 922 5047
www.stl-inc.com

## DATA QUALIFIERS AND ABBREVIATIONS

B1: This analyte was detected in the associated method blank. The analyte concentration was determined not to be significantly higher than the associated method blank (less than ten times the concentration reported in the blank).

B2: This analyte was detected in the associated method blank. The analyte concentration in the sample was determined to be significantly higher than the method blank (greater than ten times the concentration reported in the blank).

C1: Second column confirmation was performed. The relative percent difference value (RPD) between the results on the two columns was evaluated and determined to be < 40%.

C2: Second column confirmation was performed. The RPD between the results on the two columns was evaluated and determined to be > 40%. The higher result was reported unless anomalies were noted.

C3: Second analysis confirmation was performed. The relative percent difference value (RPD) between the results on the two columns was evaluated and determined to be ≤ 30%.

C4: Second analysis confirmation was performed. The RPD between the results on the two columns was evaluated and determined to be > 30%. The original analysis was reported unless anomalies were noted.

M: GC/MS confirmation was performed. The result derived from the original analysis was reported.

D: The reported result for this analyte was calculated based on a secondary dilution factor.

E: The concentration of this analyte exceeded the instrument calibration range and should be considered an estimated quantity.

J: The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

MCL: Maximum Contaminant Level

MDL: Method Detection Limit

RL: Reporting Limit

N: See analytical narrative

ND: Not Detected

X1: Contaminant does not appear to be "typical" product. Elution pattern suggests it may be __________.

X2: Contaminant does not appear to be "typical" product.

X3: Identification and quantitation of the analyte or surrogate was complicated by matrix interference.

X4: RPD for duplicates was outside advisory QC limits. The sample was re-analyzed with similar results. The sample matrix may be nonhomogeneous.

X4a: RPD for duplicates outside advisory QC limits due to analyte concentration near the method practical quantitation limit/detection limit.

X5: Matrix spike recovery was not determined due to the required dilution.

X6: Recovery and/or RPD values for matrix spike(/matrix spike duplicate) outside advisory QC limits. Sample was re-analyzed with similar results.

X7: Recovery and/or RPD values for matrix spike(/matrix spike duplicate) outside advisory QC limits. Matrix interference may be indicated based on acceptable blank spike recovery and/or RPD.

X7a: Recovery and/or RPD values for this spiked analyte outside advisory QC limits due to high concentration of the analyte in the original sample.

X8: Surrogate recovery was not determined due to the required dilution.

X9: Surrogate recovery outside advisory QC limits due to matrix interference.

[redacted]

# Chain of Custody Record

STL Seattle
5755 8th Street E.
Tacoma, WA 98424
Tel. 253-922-2310
Fax 253-922-5047
www.stl-inc.com

SEVERN TRENT STL

Client: Aspect Consulting
Project Manager: Steve Germiat
Date: 4/26/05
Chain of Custody Number: 19032
Address: 811 First Ave, Suite 480
Telephone Number (Area Code)/Fax Number: (206) 838-5830
Lab Number: 127528
Page ____ of ____
City: Seattle
State: WA
Zip Code: 98104
Site Contact:
Lab Contact:
Project Name and Location (State): Kennewick ASR
Carrier/Waybill Number:
Contract/Purchase Order/Quote No.:

Analysis (Attach list if more space is needed)

| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Matrix: Air | Matrix: Aqueous | Matrix: Sed. | Matrix: Soil | Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/NaOH | EPA 310.1 Alkalinity | EPA 310.1 $HCO_3$ | EPA 6010 Cations | EPA 300 Anions | EPA 6010 Metals by ICP | EPA 6020 Metals by ICP-MS | EPA 7470 Mercury | EPA 6010 Silica | EPA 350.1 Ammonia | EPA 160.1 TDS | EPA 160.2 TSS | EPA 110.2 Color | EPA 415.1 TOC | EPA 524.2 Trihalomethanes | Special Instructions/ Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brinkley-E01 | 4/26/05 | 11:10 | | X | | | X | X | X | X | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 8 Bottles - STL Seat |
| Source-042605 | 4/26/05 | 12:40 | | X | | | X | X | X | X | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 8 Bottles - STL Seatt |

* See attached - Full List

Cooler: ☐ Yes ☐ No Cooler Temp: ____

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☐ Disposal By Lab ☐ Archive For ____ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days): ☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☐ Other ____

QC Requirements (Specify):

| | Date | Time | | Date | Time |
|---|---|---|---|---|---|
| 1. Relinquished By | 4/26/05 | 15:15 | 1. Received By | 4/26/05 | 15:15 |
| 2. Relinquished By | 4/26/05 | 15:15 | 2. Received By | 4/27/05 | 0930 |
| 3. Relinquished By | | | 3. Received By | | |

Comments

DISTRIBUTION: WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy

## Chain of Custody Record

**STL Seattle**
**5755 8th Street E.**
**Tacoma, WA 98424**
**Tel. 253-922-2310**
**Fax 253-922-5047**
**www.stl-inc.com**

SEVERN TRENT **STL**

| | | | |
|---|---|---|---|
| Client: Aspect Consulting | Project Manager: Steve Germiat | Date: 4/26/05 | Chain of Custody Number: 19039 |
| Address: Colman Building, 811 First Ave Suite 480 | Telephone Number (Area Code)/Fax Number: (206) 838-5830 | Lab Number: 17528 | Page ____ of ____ |

City: Seattle
State: WA
Zip Code: 98104
Site Contact:
Lab Contact:
Project Name and Location (State): Kennewick ASR
Carrier/Waybill Number:
Contract/Purchase Order/Quote No.:

| Sample I.D. and Location/Description (Containers for each sample may be combined on one line) | Date | Time | Matrix: Air | Matrix: Aqueous | Matrix: Sed. | Matrix: Soil | Containers & Preservatives: Unpres. | H2SO4 | HNO3 | HCl | NaOH | ZnAc/NaOH | Analysis (Attach list if more space is needed): EPA 5542 | Haloacetic Acid | | Special Instructions/ Conditions of Receipt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brinkley - E01 | 4/26/05 | 12:10 | | X | | | X | | | | | | X | | 1 Bottle | To Edge Analytica |
| Source - 042605 | 4/26/05 | 12:40 | | X | | | X | | | | | | X | | 1 Bottle | " |
| | | | | | | | * See attached - full list. | | | | | | | | | |

Cooler ☐ Yes ☐ No Cooler Temp: ______

Possible Hazard Identification ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal ☐ Return To Client ☐ Disposal By Lab ☐ Archive For ______ Months (A fee may be assessed if samples are retained longer than 1 month)

Turn Around Time Required (business days) ☐ 24 Hours ☐ 48 Hours ☐ 5 Days ☐ 10 Days ☐ 15 Days ☐ Other ______

QC Requirements (Specify)

| | | | | | |
|---|---|---|---|---|---|
| 1. Relinquished By: Jenny M. Slack | Date: 4/26/05 | Time: 15:15 | 1. Received By | Date: 4/26/05 | Time: 15:15 |
| 2. Relinquished By | Date: 4/26/05 | Time: 15:15 | 2. Received By | Date: 4/27/05 | Time: 0935 |
| 3. Relinquished By | Date | Time | 3. Received By | Date | Time |

Comments

**DISTRIBUTION:** WHITE – Stays with the Samples; CANARY – Returned to Client with Report; PINK – Field Copy

STL8274-580 (12/02)